



QUICKLOOK AIR MOBILITY MODELING

THESIS

Mustafa K. Pektas, First Lieutenant, TUAF

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DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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Abstract In this research we focused on the mobility system modeled by the AMC mobility planners calculator (AMPCALC). We developed AMPCALC as a user-friendly tool and allow the user to easily carry out strategic airlift, air refueling and aeromedical evacuation calculations that are covered in Air Force Pamphlet 10-1403. In this study, Excel software and its macro language, Visual Basic for Application, are our two main tools. In the methodology of the thesis we examined fundamental aspects of the mobility system in AMPCALC. We discussed formulation logic of the mobility cycle. We presented ramp use optimization and tanker optimization processes. We also conducted verification and validation of AMPCALC. Sensitivity analysis of the model includes a response surface study. To be able to investigate the main effects and interaction effects of the input factors on closure time, we performed a 26 factorial design. No linear relations are observed, but some relations between inputs and closure time are observed.		
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THESIS

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Mustafa K. Pektas, BS

1st Lt., TUAF

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Mustafa K. Pektas, BS

First Lieutenant, TAAF

Approved:

James T. Moore, Lt Col, USAF (RET) (Advisor)
Associate Professor of Operations Research

Date

Raymond R. Hill, Jr., Lt Col (USAF) (Reader)
Associate Professor of Operations Research

Date

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Abstract

This research is focused on the mobility system modeled by the AMC mobility planner's calculator (AMPCALC). AMPCALC is developed as a user-friendly tool and allows the user to easily carry out strategic airlift, air refueling and aeromedical evacuation calculations that are covered in Air Force Pamphlet 10-1403. In this study, Excel software and its macro language, Visual Basic for Application, are two main tools.

The methodology of the thesis examines fundamental aspects of the mobility system in AMPCALC. Formulation logic of the mobility cycle is discussed. Ramp use optimization and tanker optimization processes are presented. Verification and validation of AMPCALC is conducted.

Sensitivity analysis of the model includes a response surface study. To be able to investigate the main effects and interaction effects of the input factors on closure time, a 2^6 factorial design is performed. No linear relations are observed, but some relations between inputs and closure time are observed.

QUICKLOOK AIR MOBILITY MODELING

I. Introduction

General Issue

At the beginning of the new millennium, dynamic military events around the world have increased in pace and intensity. Because of this, the emphasis on the deployment of forces and material from their homeland to the operational arena has become more important and essential. This is especially true for those countries that have crucial missions in this arena. Among these countries, the United States of America, as a world military power, has a large and challenging requirement for military movement.

When it is necessary to exert military pressure over substantial distances, airlift operations play a crucial role in performing and supporting these actions. The capability to mount strategic transport operations--defined as the airlift of personnel and cargo between theaters of military activity or major geographical areas--is particularly important to any state which aspires to project its influence beyond its borders. This does not mean, of course, that inter-theater operations are exclusively conducted within the context of power projection. On the contrary, strategic airlift has many applications including aeromedical evacuation, the resupply or reinforcement of existing garrisons, support for exercises, and humanitarian relief operations. Whatever and wherever the

mission is, inside or outside of the country, there are some principles that must be observed if airlift assets are to be exploited in the most effective and economical manner.

One of these principles is to properly assess and resolve conflicting demands and priorities. This is especially important where strategic and large tactical airlifters are concerned, since the correct employment of such aircraft could be crucial to the success of airlift operations. The other principle is to execute the operation with the maximum economy. This is important, because airlift operations are usually expensive operations (Chapman, 1989: 14-16). Another concern is time, since it is very important to be able to execute the airlift operation within proper time limits.

Therefore, in airlift operations, making a “good” assessment of system delays is critical to getting a “good” answer, which a decision maker can use to direct the airlift fleet. For example, consider an airlift cycle with one starting/onload point, two enroute points, one offload point and a need for 40 missions to carry all cargo and passengers to the offload point. With a simple calculation, we can see that a one-hour delay at each of the points in the above cycle can cause a delay of more than 6 days (Merrill, 1992: 7). Therefore, the success of the airlift operation depends on these principles. In any airlift operation, the decision maker needs accurate analysis and good solutions concerning the use and application of limited resources such as aircraft, aircrews and materials.

Background

Air Mobility Command Study and Analysis Division (AMC/XPY) uses an Excel spreadsheet model, Airlift Cycle Analysis Spreadsheet (ACAS). ACAS was developed in 1989 to perform the calculations outlined in Air Force Pamphlet (AFPAM) 76-2 and

was updated and superseded in 1998 by new AFPAM 10-1403, Airlift Planning Factors. Air Force Pamphlet 10-1403 provides broad air mobility planning factors for peacetime and wartime operations. It is designed to help service, joint, and combined planners make gross estimates about mobility requirements in the early stages of the planning process. It covers strategic airlift, air refueling, and aeromedical evacuation (AE) (Edgington, 1 March 1998: 1). Cycle time, closure time, fleet capability, ground times and aircraft block speeds are some of the mobility planning factors and formulas that AFPAM 10-1403 contains.

ACAS, however, does not use all of the mobility planning factors that are addressed by AFPAM 10-1403. Although it incorporates strategic airlift factors, it does not have any air refueling and aeromedical evacuation (AE) formulas. The ACAS user enters airlift operation input values like aircraft capability, standard planning factors, cargo type permission and aircrew limit input values and ACAS calculates related outputs such as cycle mission statistics, cycle capability statistics, cycle flow interval limits, cycle throughput, and closure times. In addition, ACAS contains no formulas or factors for air refueling.

When it was first introduced, ACAS was used to educate new mobility analysts and to perform quick airlift analyses. It still has this function; however, it allows the user to evaluate the airlift system performance of just two simultaneous cycles using up to eleven different aircraft types.

According to the ACAS User's Manual, ACAS is a deterministic model rather than a simulation. When the user enters the input parameters, the model gives fixed output measures. Many assumptions are made when fixed average airlift system numbers

are used. It is incumbent upon the user of ACAS to intelligently research and methodically input appropriate cargo requirements, aircraft fleet descriptions, allocated aircraft numbers, location capability constraints, crew call-up and flying hour limits, proper routes, enroute wind conditions, and all associated average times, speeds and distances. The user should recognize that the insights provided by the ACAS output are limited by the assumptions of smooth flow, perfect command and control, and a large set of fixed parameters, which may be highly variable in the real world. For example, there may not always be a smooth flow of cargo and passengers, so aircraft do not take off fully loaded. All of the locations in an airlift network may not be operating 24 hours a day and seven days a week until closure occurs. Weather conditions can cause some flight delays or cancellations. Airfields may not be available for use during the airlift operation. Although there is a significant amount of "if-then" logic built into ACAS, there is no provision for stochastic changes over time or for changing conditions. For example, daily changes in numbers of aircraft, crews, or operating locations would have to be averaged as a single input or multiple runs would have to be made reflecting daily conditions. The real advantage of this model lies in the ability of an analyst to rapidly evaluate airlift throughput measures given aggregate, average input conditions (Merrill, 1992: 7,10).

Another critical factor in recent airlift analyses is the daily fuel pumping capacities at enroute bases. Many overseas bases are equipped with old fuel systems and limited abilities to refuel multiple aircraft simultaneously. Others have small bulk storage capacity. Due to these limitations, accurate airlift planning needs fuel to be

explicitly represented in the planning equations. So, the base fuel storage and replenishment capacities and aircraft fuel burn equations are needed.

Since its sequences of calculations are difficult to follow, ACAS needs a better spreadsheet layout. Moreover, to be able to calculate flying distances, the user goes to another spreadsheet named Distance Calculation Spreadsheet (DISTCALC) and performs distance calculations off-line instead of in an on-line environment.

Research Goal

In this study, the goal is to develop a new spreadsheet model, the AMC Mobility Planner's Calculator (AMPCALC) that allows the user to easily carry out the various calculations contained in Air Force Pamphlet 10-1403 and expand these formulas to include more complex air networks and mixed airlift fleets in a more user friendly environment.

AMPCALC Overview

In order to represent more complex airlift scenarios, AMPCALC contains four independent cycles in which each cycle uses aircraft and aircrew resources independently. AMPCALC has airlift formulas, and it also implements air refueling formulas and aeromedical evacuation formulas as well for each independent cycle. The allowable number of aircraft types in the model is 15 and this allows the inclusion of future aircraft types. Moreover, the spreadsheet is user-friendlier and takes advantage of Visual Basic's interactive development environment (IDE) such as check boxes, text boxes, user forms, command buttons, combo boxes, and drop-down boxes. The user no longer has to calculate flying distances off-line. The new model makes the block speeds

and aircraft payload / range calculations clearer and more concise. AMPCALC also provides new mobility analysts with an education tool that does quick airlift analyzing exercises with its better spreadsheet layout. It has an enhanced acronym and definition glossary, and it has formulation screens and screen information pages in a button-click format. To be able to expand and enhance the decision logic of the model, additional approaches and LPs are applied and the results are evaluated. While introducing these new features and capabilities in the new model, AMPCALC keeps the current capabilities of ACAS and does not lose any of its previous functionality.

Scope of Research

This study is related to the AMC operational factors provided by Air Force Pamphlet 10-1403 and the ACAS spreadsheet itself. During the development and evaluation stage of AMPCALC, close coordination was needed with the mobility analysts in AMC/XPY to be able to evaluate accomplishment of the objectives, test the new model, and eliminate modeling difficulties.

Overview of Thesis

This thesis is divided into the following five chapters: Introduction, Literature Review, Methodology, Analysis and Conclusion, Further Improvements. A brief description of each follows.

Chapter 1: Introduction - This chapter discusses the background of ACAS, presents the goal of the research, and provides an overview of AMPCALC.

Chapter 2: Literature Review – This chapter first discusses Development of Programming Languages, then presents Object-Oriented Programming and Visual Basic,

Visual Basic for Applications, and VBA's advantages in model development. ACAS and AFPAM 10-1403 are also presented. Finally, response surface methodology and verification and validation study of the model are discussed.

Chapter 3: Methodology – This chapter first presents how AMPCALC was modeled and the major equations used in the model. Then, AMPCALC's tanker and ramp use optimization processes are discussed.

Chapter 4: Analysis and Conclusion – This chapter presents the sensitivity analyses of AMPCALC and discusses the effects of some input factors on closure time.

Chapter 5: Further Improvements – This chapter presents areas for possible study.

II. Literature Review

Introduction

This chapter presents a review of the literature that was used while doing this study. In the statement of work (see Appendix A) for AMPCALC, it says Microsoft Excel and its internal macro language VBA are office system standards that are being used widely in the Air Force, so AMPCALC is written using these software packages to increase its applicability. Therefore, this chapter first provides a brief background on the development of programming languages, then, while discussing object oriented programming as an evolutionary product of programming languages, it introduces the Visual Basic (VB) programming language. Then, it explains a variation of Visual Basic, Visual Basic for Applications (VBA), which was initially developed for Microsoft's Excel. Then, VBA's advantages in our modeling are discussed. This chapter discusses AMPCALC's two main sources of information, the Airlift Cycle Analysis Spreadsheet (ACAS) and Air Force Pamphlet 10-1403. This chapter also discusses response surface methodology and verification and validation study of AMPCALC.

Development of Programming Languages

The introduction of the microcomputer heralded the beginning of computing for the masses. The first computer was a \$400 box of jumbled wires, switches, and lights that did little more than "beeps" and "blinks". Prior to the introduction of the microcomputer, computers occupied entire rooms, and only large corporations and government agencies could afford them. Through advancements in computing technology, computers have shrunk in size and become affordable to the public. In the

mid 1970s, a large computer hobbyist community, in which people bought parts and built crude computers with the purchased parts and blueprints, quickly developed. These early entrepreneurs sold the computers to small businessmen, doctors, students, professionals and other users (Kim, January 1991: 21-28).

After its development, the microcomputer was rapidly adopted and this revolutionized the computing landscape as people quickly realized that the microcomputer would become vital to business. The proliferation of the microcomputer (personal computer) also brought new ideas and innovations to the software industry and inspired it to create a variety of languages and applications.

More than a hundred different programming languages have been used in the computing world and each was developed to solve particular problems or meet specific needs. Early languages are mostly high-level languages with structured programming. The language structures are organized into data structures such as lists and trees. Algorithms for searches and sorts are well established. A good example of an early programming language is BASIC (BASIC stands for Beginner's All-purpose Symbolic Instruction Code). BASIC was one of the earliest, widely adopted languages for the microcomputer. Thomas Kurtz and John Kemeny from Dartmouth College designed the first BASIC language in the 1960s for use by the Dartmouth student body. Before the introduction of the BASIC language, early applications were custom made for each unique computer. BASIC was designed to be a common language that could be used by most computers, thus allowing greater accessibility to people (Kim, January 1991: 21-28). The hobbyists and programmers gathered into communities and began to share ideas and knowledge. As programming languages made computers and programming

accessible to more hobbyists, this increased access naturally lead the hobbyists to develop more software and to pursue innovations in software and language development.

C, COBOL, FORTRAN and Pascal are other early procedural languages. They were an excellent initial step for early application. Over time, personal computer usage spread and newer applications became complex. As tasks, application functionalities, and program and application sizes grew, the procedural languages were no longer sufficient to meet the needs of computer users.

Object-Oriented Programming and Visual Basic (VB)

Visual Basic (VB) is one of today's popular computer languages. It is descended from the computer language BASIC. In 1991, when Microsoft Corporation first released Visual Basic for Windows, it offered many new and different properties that are not included in the BASIC language. With these new properties, Visual Basic found its place in today's computer user arena.

During the last 25 years, one of the most significant innovations in the software industry is arguably the wide adoption of object-oriented programming (OOP). Alan Kay, a researcher at Xerox Palo-Alto Research Center (PARC) coined the term 'object-oriented programming' and created the principles of OOP. Kay predicted that personal computers in the near future would be widely used and networked together. He also stated that software must have three characteristics to ensure widespread adoption: zero replication time and cost, low development time and cost, and low revision time and cost. The basic idea of OOP languages is to create 'objects' in programs that are easy to create, understand, use and reuse. Kay used his OOP principle to create the Smalltalk language.

He theorized that languages would be easier to write based on models that were easier to understand. In addition, programs that are easier to read are easier to maintain, reducing the largest cost associated with software. Object-oriented languages like Smalltalk enable the adoption of a graphical user interface (GUI) by making them easier to use and reuse. The GUI improved the interaction between people and machines by creating an intuitive interface between the user and the computer. Programmers can reuse the same scrollbar and buttons for different programs. This reduces development time and cost. The buttons, scrollbars, and other GUIs become familiar to regular developers and users, helping to spread the popularity of the computer. Early GUIs eventually evolved to more general software components and objects. The focus of objects is to create fully functional applications by linking together pre-written objects using minimal coding. This maximizes reuse and minimizes change time and cost. (Kim, January 1991: 21-28)

Object-oriented programming helped lay the foundation for advances in software engineering such as testing techniques and programming methodologies. By the early 1990s, software designs were becoming more complex. By analyzing well-designed object-oriented software and applications, programmers discovered, identified and cataloged key patterns. By using these patterns, programmers could quickly develop robust applications that compile and execute quickly and efficiently.

In the computer world, there are hundreds of programming languages. Each of these languages was developed for specific types of problems. As discussed in the previous section, most traditional languages, such as BASIC, C, COBOL, FORTRAN, PL/I, and Pascal, are considered procedural languages since they are typically executed in sequential operations and the program specifies the exact sequence of all operations.

Their program logic determines the next instruction to execute in response to conditions and user requests. On the other hand, in an event-driven language like Visual Basic, programs are no longer procedural; they do not have a particular sequential logic. Instead, the user can press keys and click on various buttons and boxes in a window. Each of these actions causes a specific event to occur. However, like the programming language C++, Visual Basic uses object-oriented programming and event-driven programming. Microsoft refers to Visual Basic as an event-driven programming language, which has many elements of an object-oriented language such as Java, but not all of them. The combination of OOP and event-driven modeling maximizes the reuse of codes and minimizes development time. With release of each new Visual Basic version, (currently Version 6.0), it becomes closer to a true object-oriented language (Bradley *et al.*, 1999: 3).

Visual Basic for Applications (VBA)

Visual Basic for Applications is the widespread macro language for Microsoft Office Applications such as Microsoft Excel, Word and PowerPoint. The word “macro” refers to a procedure and is a sequence of instructions that are performed automatically to execute some specific standard and repeatable functions. The macro language is a featured language with a specific macro standard that enables a user to create his/her own macros. MS Excel has its own macro language, VBA; however, there are other computer software packages, such as Lotus 1,2,3, Python and AMPL, which have their own macro scripting languages. VBA was introduced in Excel 5.0. Prior to that version, Excel used an entirely different macro system standard, known as XLM (that is, the Excel

4 macro language). VBA is far superior in terms of both power and ease of use. For compatibility reasons, however, the XLM language is still supported in Excel 2000. This means that you can load an older Excel file and still execute the macros that are stored in it. However, Excel 2000 does not let you record XLM macros (Walkenbach, 1999: 756).

The ability to use a macro recorder is one of the biggest benefits of using VBA in a host application since you can generate basic code for an application. VBA allows the programmer to record a macro. Macro recording is a process, which converts some actions into VBA code automatically. It is a good device for learning. However, some actions, such as looping, cannot be recorded via macro recorder. Macro recording is a feature that is not found in the Visual Basic package itself (Gates, March 1998: 70-72). The VBA Macro recorder works similar to a VCR. The programmer presses the record button, and the recorder generates code for every action the programmer performs, until the recorder is stopped. This allows the programmer to rapidly generate codes for use and reuse on the “fly.” This also helps novice programmers learn new functions and create new codes without extensive training and time. The Macro recorder is the first widely available usable code generator in the computing world (Keily, 1997: 10-12).

The underlying language in both Visual Basic and VBA is the same. Since they share a common engine, the only substantial difference is that a VBA application can run only within the VB host application. Visual basic generates separate executable files that run outside of the host application while VBA does not.

Visual Basic for Applications (VBA) is a branch of the Visual Basic language. Although these two languages are essentially identical, VBA is not a stand-alone package like VB. You cannot buy and run VBA separately. The “for Applications” in Visual

Basic for Applications means that any application software package, such as Excel, Access, Word, or even a non-Microsoft software package, can “expose” its “objects” to VBA, so that VBA can manipulate them programmatically. Thus, VBA can be used to develop applications for any of these software packages. For example, VBA for Excel can manipulate and use Excel objects such as Application, Range, Worksheets and Charts. VBA can also be used to change the font of a worksheet, name a chart or workbook and activate a range (Albright, 2001: 5-6).

The Integrated Development Environment (IDE) of VBA has some basic programming tools for achieving VBA functions. These are: Visual Basic Editor, Microsoft Forms, the object browser, and the debugging tools. The Visual Basic Editor is the standard programming interface for VBA. It allows the programmer to write and manage codes within an application. The Microsoft Forms is a user-friendly interactive graphical user interface (GUI) template. Interactive features such as Command Buttons, Check Box, and Pull-Down Menus can easily be added with a few clicks of a mouse with little coding. The object browser shows all the separate components of the application, such as objects, macros, forms and modules, contained in the application. The debugging tools and help features are the same features contained in VB. They are context-sensitive, and provide the programmer with a helpful tool during his/her debugging process via the IntelliSense feature which means having the ability to find the complete format or syntax of the user’s input by itself. These features allow application programmers and users to take an existing application and modify it for their own use or to build new applications. “Beyond the fact that this gives programmers a nice Integrated Development Environment (IDE), VBA built a big following among software

developers.” Visual Basic for Applications balances an easy-to-use development environment with a sophisticated set of functions, including an advanced debugger (Larsen, 1998: 33-34).

VBA’s Advantages for This Study

The most important advantage of VBA in this study is its extensive applicability throughout the air mobility community and the Air Force. Since Microsoft dominates today’s desktop operating system, Visual Basic inherits this dominance in the many Windows applications used everyday. The Visual Basic core is also used to build many of the standard desktop applications such as Word and Excel. Hundreds of companies have also adopted Visual Basic and VBA as their interoperability language and development environment. There are about 3 million Visual Basic developers today and Microsoft still has a gigantic VB community (Sliwa and Thibodeau, 2001:16). As a result of all this, many users have acquired the ability to create familiar user interfaces in a short time. This is another advantage of VBA. Especially for novice planners familiar with the Windows environment, this allows quick learning of new applications through familiar user interfaces. Thus, a user-friendly environment is created for both AMPCALC users and planners. AMPCALC also uses the VBA macros to solve optimization problems of varying size. This property also shows VBA’s advantage and usability in our study.

The Airlift Cycle Analysis Spreadsheet (ACAS)

Many mobility models have been used in the military arena. The Airlift Cycle Analysis Spreadsheet (ACAS), a computerized spreadsheet in the area of air mobility

modeling (see Appendix B for others), is a main source for this study along with Air Force Pamphlet (AFPAM) 10-1403. In the ACAS User Manual, it says that ACAS allows the user to evaluate the airlift system performance of two simultaneous cycles, using up to eleven different aircraft types. Then it indicates the basic sources of ACAS as the following:

- The cycle analysis methodologies of old AFPAM 76-2 (new AFPAM 10-1403 Airlift Planning Factors),
- The AMC Airlift Planning Guide,
- The Airlift Operations School Airlift Capabilities and Contingency Planning Seminars,
- The USAF Airlift Master Plan (Department of the Air Force, 1995) and Desert Shield/Storm experience (Merrill, 1992: 3).

Since ACAS is a deterministic model, there are no stochastic changes during the time intervals in the model. The user enters values such as Aircraft Capability, Cargo Requirements, and Aircrew Limits and the model rapidly calculates output values such as Throughput, Closure time, Capability Statistics, and Crew Summary. ACAS's airlift cycle starts from the departure point fully loaded, passes through its enroute points, offloads its cargo and passengers at an offload point and then returns to home base following the same route. An ACAS cycle ends when all cargo and passengers are delivered. As mentioned in the first chapter, ACAS incorporates several assumptions. These are: smooth cargo and passenger flow, perfect command and control, and many fixed parameters which are actually variables in reality. Some examples are weather conditions, air crew availability, air field operation availability and unplanned enroute base restrictions.

Air Force Pamphlet 10-1403 (Air Mobility Planning Factors)

Air Force Pamphlet 10-1403 consists of four basic parts. They are terms and definitions, formulas, planning factors, and examples (Edgington, 1998: 2). Since ACAS does not include the terms, definitions and formulas sections of this Pamphlet, they are included in the glossary and formulas sections of this study's model, AMPCALC. Additionally, the planning factors of the Air Force Pamphlet 10-1403 include formulas for strategic airlift, air refueling, and aeromedical evacuation. Air refueling and aeromedical evacuation (AE) formulas are not included in ACAS, but they are added to AMPCALC.

Response Surface Methodology for AMPCALC's Sensitivity Analysis

Response surface methodology (RSM) includes some statistical and mathematical techniques for developing, improving and optimizing processes. RSM examines the input variables' potential influence on performance measures or quality characteristics of the product or process. Two level factorial designs are a very important special case of factorial designs in RSM, which have 2^k experimental trials (Myers and Montgomery, 1995: 79). Two level full factorial designs allow us to investigate all interaction effects as well as main effects of the input parameters in the model.

In general, the true response function of the process is unknown, so, scientists or engineers try to determine the approximate response function of the true response function as a function of the controllable input variables. This approximate response function has some source of variability which is also called statistical error (Myers and Montgomery, 1995: 1-3). The less statistical error there is, the more closely

approximation matches the true function. However, any fitted deterministic linear regression model would exactly match with the true response function and has a zero pure error value.

Giddings, Bailey and Moore are used experimental design and least squares regression to indicate which cost coefficients have the greatest impact on the optimal total cost response surface over the specified coefficient ranges in their study (Giddings *et al.*, 2001: 38-52). Their model is a deterministic mathematical program. In their sensitivity analysis some cost coefficients in a mixed integer linear program are selected as factors and lower and upper bounds are specified. They design an experiment to get the response surface of their deterministic model. In their design they also add a center point run for each factors in addition to experimental runs for assessment of the curvature. With the appropriate number of center point rows in the data table, sum of square analysis is performed by the statistical software package and sum of squares of models and error is taken. Since their model was deterministic, the standard statistical tests for assessment of curvature or lack of linear fit are not appropriate. Instead, they use the R^2 value to indicate the level of curvature present when a linear regression model has been fitted to the data. They imply that when they design a response surface model to estimate a higher-order functional form for the model the only error present is the lack of fit error of the regression model and it is determined by R^2 . If R^2 decreases it means the curvature increases. They also explain that why they add multiple center points to the model. According to their explanation, since the underlying system is deterministic, one objection to including multiple center points is adding information already included in the model. However, varying the number of center point rows simply controls the relative

weight of the responses presented when fitting the regression model. For instance, if a single center point row is used in all cases, R^2 will not provide a consistent assessment of curvature in the underlying response. Therefore, the center point row should be replicated in the table one time for each factor in the design. The addition of center points to the model affects only the intercept term in the regression equation and the coefficients of the factors represented in the regression equation indicate the relative importance of each factor in the design (Giddings *et al.*, 2001: 38-52).

Our study in sensitivity analysis for AMPCALC takes advantage of RSM. With the help of a response surface model, we acquire better understanding about the mobility modeling process in AMPCALC. We use a 2^6 full factorial design with 6 center runs where each of the 6 factors has two levels. AMPCALC is not a probabilistic model just as the model in study of Giddings *et al.* (2001); every time we enter the same input set, the model produces the same results. Therefore, no pure error is produced when linear regression model is fitted to its data. We discuss model's curvature and some effects of its inputs on closure time in Chapter 4.

Verification and Validation of AMPCALC

Law and Kelton (Law and Kelton, 2000: 264) define and describe verification and validation. According to their definitions, verification involves determining whether or not the conceptual model have been correctly translated into a computer program. If the model to be verified is not a complex one, the verification process is not a hard task. However, the more the model represents the real world, the more complex it is. They

also present some verification techniques that we have applied while developing AMPCALC. For example:

- Write and debug the program in modules or subprograms,
- Have the program reviewed by more than one person during the development process,
- Run the model under a variety of settings of the input parameters, and check to see that the output is reasonable.
- “Trace” each program path and evaluate its performance using different input values.

Even if the model obviously works well and does not produce any errors, it still needs a significant level of study to confirm its validity. Validation is the process of determining whether or not the model is an accurate representation of the system. The model that will be validated may not reflect the actual system exactly but only be an approximation to the actual system. Therefore, there is no such thing as absolute model validity (Law and Kelton, 2000: 265). The following presents as some techniques of Law and Kelton that are applied to AMPCALC.

In developing a model, the data used included

- Conversations with subject-matter experts
- Using relevant results from similar models
- Interact with the manager on a regular basis

while using outputs to,

- allow the subject-matter experts to use and try the model with real time scenarios (expert validity);
- compare model outputs with perceived system behavior (face validity); and

- check consistency between the model outputs and system behavior, when making changes in the model (calibration of the model) (Law and Kelton, 2000: 274-282)

All these techniques' result helped establish the models credibility for the planners who will use the model. The next chapter presents the development of AMPCALC.

III. Methodology

Introduction

Chapter 3 presents the mobility system and how it is modeled in AMC Mobility Planner's Calculator (AMPCALC). First, how the mobility system is modeled and the major equations used in the model are discussed. Then, two optimization processes in the model, tanker optimization and ramp use optimization, are presented.

The Mobility System In AMPCALC

There are different kinds of mobility models designed for different mobility purposes and used for different deployment phases (see Appendix B). However, each relies on similar mobility system requirements and definitions. The model of our study deals with the airlift dimension of the mobility modeling process. It may be used to study global or theater (regional) airlift missions. Figure 3-1. Airlift Cycle, schematizes the simple airlift cycle of a typical mission of this study. The airlift cycle shows the airlifter departing its home station, usually known as ports of embarkation (POE) (a point for cargo/passengers (pax) to deploy from) and completing its mission via passing through the enroute points and destination point or ports of debarkation (POD) (a point for cargo/pax to deploy to) and then returning to the home station.

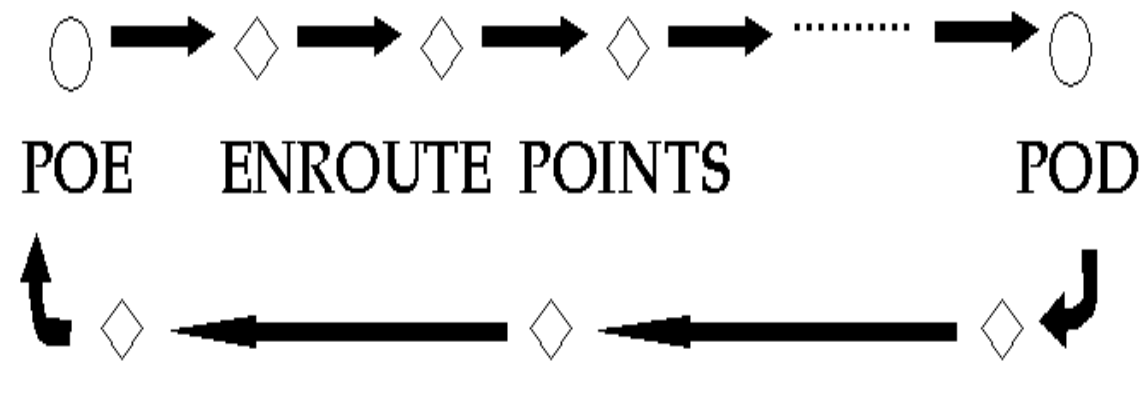


Figure 3-1. Airlift Cycle

The airlift cycle of the mobility system we are modeling may include six different types of stopping points. These are a waypoint without a stop, onload point, enroute point, offload point, engine running offload (ERO) point and home station or other network location for which a non-standard ground delay occurs. A waypoint without a stop just shows the route of the aircraft and has no ground time in the model. However, other stopping points have different ground times. Ground time is the average amount of time an aircraft spends on the ground for cargo onload/offload, fuel/maintenance servicing and non-standard ground delays. Ground times vary by aircraft type. The total of all ground times in a round trip, from POE through enroute points and POD and back to the POE, is round trip ground time. The flying time of a round trip, round trip flying time, is the sum of the ratios of each leg distance divided by block speed. Block speed is the average true airspeed of all flight phases such as takeoff, climbing, approaching and landing for a single sortie under zero wind conditions. Block speed's unit is nautical

miles per hour (nm, 1 nm. = 6076.115 feet = 1852 meters). The sum of round trip flying time and round trip ground time is airlift cycle time. In the system, all times are in hours. Leg block speeds are calculated by dividing leg distance by the elapsed time between brake release on take off to parking brake after landing. All distances are in terms of nautical miles (nm) and all speeds are in terms of nautical miles per hour (nm/hr). Equations (1), (2), and (3) show the computation required to determine round trip ground time, round trip flying time, and cycle time, respectively.

$$\begin{aligned} \text{Round Trip Ground Time} = & \text{Onload Time} + \\ & \{(\text{Enroute Time}) \times (\text{Number of Enroute Stops In} \\ & \text{Cycle})\} + \text{Offload Time} \end{aligned} \quad (1)$$

$$\begin{aligned} \text{Round Trip Flying Time} = & (\text{Leg Distance}_1 / \text{Block Speed}_1) + \\ & (\text{Leg Distance}_2 / \text{Block Speed}_2) + \dots \\ & (\text{Leg Distance}_n / \text{Block Speed}_n \end{aligned} \quad (2)$$

$$\text{Cycle Time} = \text{Round Trip Ground Time} + \text{Round Trip Flying Time} \quad (3)$$

In modeling the mobility system, we assume each aircraft in the system starts another cycle as soon as its previous cycle is completed. This process goes on until all cargo/pax are delivered to the POD. Smooth flow of cargo and passengers is assumed in the model which means there are always cargo and pax available at the onload point unless all cargo/pax requirements have been met. We also assume that all stop points in the cycle work continuously. The total number of missions required is the sum of the number of cargo and pax missions. The number of cargo missions is the total cargo to be carried divided by the aircraft's average payload capacity. Based on user specification,

our model of the mobility system chooses one of the two average payload capacity values. The first payload value is a statistical value derived from the air mobility master plan and the second is the desert storm long-term average payload value for each aircraft in the model. Then, the chosen payload value is compared with the payload value that is a function of travel distance and the smallest of these is used in the model. Our mobility system uses Air Force Pamphlet 10-1403 range payload tables to determine the distance related payload value for each aircraft type. The cargo carrying capacity of an aircraft decreases as the distance flown increases because the aircraft needs more fuel as it flies greater distances.

In the model, an aircraft might be allowed to carry both cargo and pax together if it has such capability. So, the number of pax missions is calculated as the difference between total pax and pax on the cargo missions divided by the pax mission capability of the aircraft. “Short ton” is the load measurement of the system. Payload and cargo values are in terms of short tons and 1 short ton equals 2000 pounds. Equations (4), (5), and (6) show the computation required to determine the number of cargo missions, number of pax missions, and total missions required, respectively.

$$\text{Number of Cargo Missions} = \text{Cargo Requirement} / \text{Average Payload} \quad (4)$$

$$\text{Number of Pax Missions} = (\text{Total Pax} - \text{Pax on Cargo Missions}) /$$

$$\text{Pax Capability per Pax Mission} \quad (5)$$

$$\text{Total Mission Required} = \text{Number of Cargo Missions} + \text{Number of Pax Missions} \quad (6)$$

Cargo categories are not standard so the capability of each aircraft type by cargo category is needed. There are three main cargo categories. Bulk cargo fits on a standard pallet and can be carried by all cargo aircraft. Oversize cargo exceeds the dimensions of a standard pallet but is less than 1090''X 117'' X 105''. Oversize cargo can only be carried by C-5, C-17, C141 and KC-10 (partly, because of its special inner loading structure). Outsize cargo is the largest cargo category of all. It includes the cargo that exceeds the oversize dimension and can only be carried by the C-5s and C-17s.

The performance of the mobility system that is modeled is affected by the flow interval of the system. The flow interval value is the maximum of other minor intervals. These are station interval, aircraft allocation interval, flying hour capability interval, and stage crew interval. The maximum of these intervals is the most constraining one in the model.

Station interval is the ratio of station ground time, which is the expected time between aircraft engine stop after landing and aircraft takeoff time, to station capability, which is the number of aircraft that could be serviced by the station during expected ground time. Aircraft allocation interval equals cycle time divided by all available aircraft. Available aircraft are the number of aircraft allocated for a mobility mission. These aircraft constitute the primary mission aircraft inventory (PMAI) allocation where PMAI is the total aircraft inventory (TAI) minus the backup aircraft inventory (BAI) and training force (TF) aircraft. The flying hour capability interval shows the aircraft utilization (ute) rate of the system and is a function of the objective ute rate in terms of hours per day. Ute rate is a planning factor. For each aircraft type, its ute rate represents the daily flying time for each aircraft of that type in the fleet. Objective ute rate includes

system delays such as maintenance, supply, and air traffic, which are not directly modeled. Stage crew interval represents the crew-originated constraint in the system and is a function of crew rest period, aircraft ground time and number of stage crews. The computation of station interval, aircraft allocation interval, flying hour capability interval, and stage crew interval are shown in the equations (7), (8), (9), and (10), respectively. Equation (11) shows the computation required to find the flow interval value. In the equations below, all the intervals and times are in terms of hour and objective ute rate is in hours/day.

$$\text{Station Interval} = \text{Station Ground Time} / \text{Station Capability} \quad (7)$$

$$\text{Aircraft Allocation Interval} = \text{Cycle Time} / \text{PMAI Allocation} \quad (8)$$

$$\text{Flying Hour Capability Interval} = (\text{RTFT} \times 24) /$$

$$(\text{Objective Ute Rate} \times \text{PMAI Allocation}) \quad (9)$$

$$\text{Stage Crew Interval} = (\text{Crew Rest Period} - \text{Aircraft Ground Time}) /$$

$$\text{Number of Stage Crews} \quad (10)$$

$$\text{Flow Interval} = \max \{ \text{Station Interval}, \text{Aircraft Allocation Interval}, \text{Flying Hour}$$

$$\text{Capability Interval}, \text{Stage Crew Interval} \} \quad (11)$$

The time period required to deliver all cargo/pax from POE to POD is closure time; closure time is a measure of system performance. Closure time is a fundamental output of our mobility model. The maximum of the cargo and pax closure time determines the final closure time. Although the aircraft numbers are allocated

beforehand in the system, the prime aircraft, which is the minimum number of airframes necessary to support a cycle from the POE to the POD and returning to the POE, is calculated and then closure time is estimated. All aircraft above the prime number of aircraft have no effect on closure time. Equations (12) and (13) show the prime aircraft required and closure time computations, respectively.

$$\text{Prime Aircraft Required} = \text{Cycle Time} / \text{Flow Interval} \quad (12)$$

$$\text{Closure} = [(\text{Missions Required} - 1) \times (\text{Flow Interval}) + \text{One-Way Enroute Time}] / 24 \quad (13)$$

One-way enroute time is the time period between onload and offload. Closure time does not include the aircraft's last flight time back to its home base. Closure time is measured in terms of days.

Although there are many types of aeromedical evacuation, the mobility system modeled here does not consider mission distance or patient and mission types. Aeromedical evacuation is modeled so as to determine an estimation of the number of aeromedical missions and medical crews needed given the number of patients per day. Our mobility model calculates required aeromedical evacuation missions per day by dividing the number of patients by a load planning factor, where this load planning factor shows the standard number of aeromedical evacuation patients loaded per aircraft. Required crews are determined by multiplying missions per day, a crew planning factor, crews per aircraft, and crew cycle time. Load planning factor, crew planning factor, crews per aircraft, and crew cycle time values are not entered by the model user. They

are the values taken from AFPAM 10-1403. Equations (14) and (15) show the computation required to determine aeromedical evacuation mission per day and aeromedical evacuation crew, respectively.

$$\text{Aeromedical Evacuation Missions per Day} = \frac{\text{Number of Evacuees per Day}}{\text{Load Planning Factor}} \quad (14)$$

$$\text{Aeromedical Evacuation Crew} = \frac{\text{AE Missions per Day} \times \text{Crew Planning Factor} \times \text{Crews per Aircraft} \times \text{Crew Cycle Time}}{\text{Crews per Aircraft} \times \text{Crew Cycle Time}} \quad (15)$$

AMPCALC is also designed to determine air refueling requirements of airrefuelable fighter/airlift aircraft for a specific flight leg. The air refueling process works independently from the airlift cycle process and can be repeated for different flight legs. However, if the leg is too long, fuel offload available per tanker drops under zero and the solution becomes infeasible. Even if higher tanker numbers are entered, the infeasibility would still exist. It is not designed for a complete cycle nor does it consider receiver-tanker relations which may have effects on the process. These effects include air refueling altitude, control point, exit point, and aircraft configuration. In the model, fuel offload requirements for each receiver and fuel offload available from each tanker are a function of total distance from takeoff to landing, average air speed, fuel burn rates, total fuel on board at take off and required fuel reserves at destination. Once the system determines fuel offload required and fuel offload available, it allocates requirements to

the available tanker aircraft while considering their capacities. Equation (16) shows the computation of required fuel amount per receiver aircraft while Equation (17) shows available fuel amount per tanker aircraft for specific leg distances in the air refueling process.

$$\begin{aligned} \text{Fuel Offload Required per Receiver} = & (\text{Distance} / \text{Average Airspeed} \times \text{Fuel Burn} \\ & \text{Rate}) - \text{Total Fuel} + \text{Destination Reserves} \end{aligned} \quad (16)$$

$$\begin{aligned} \text{Fuel Offload Available per Tanker} = & \text{Total Fuel} - (\text{Distance} / \text{Average Airspeed} \times \\ & \text{Fuel Burn Rate}) - \text{Destination Reserves} \end{aligned} \quad (17)$$

In Equations (16) and (17), distance is nm, airspeed is nm/hr, fuel burn rate is lbs/hr, and all fuel weights are lbs. Destination reserves value is the input value which shows aircraft's required reserve values at destination point.

Figure 3-2. shows the mobility inputs, calculations and outputs of AMPCALC.

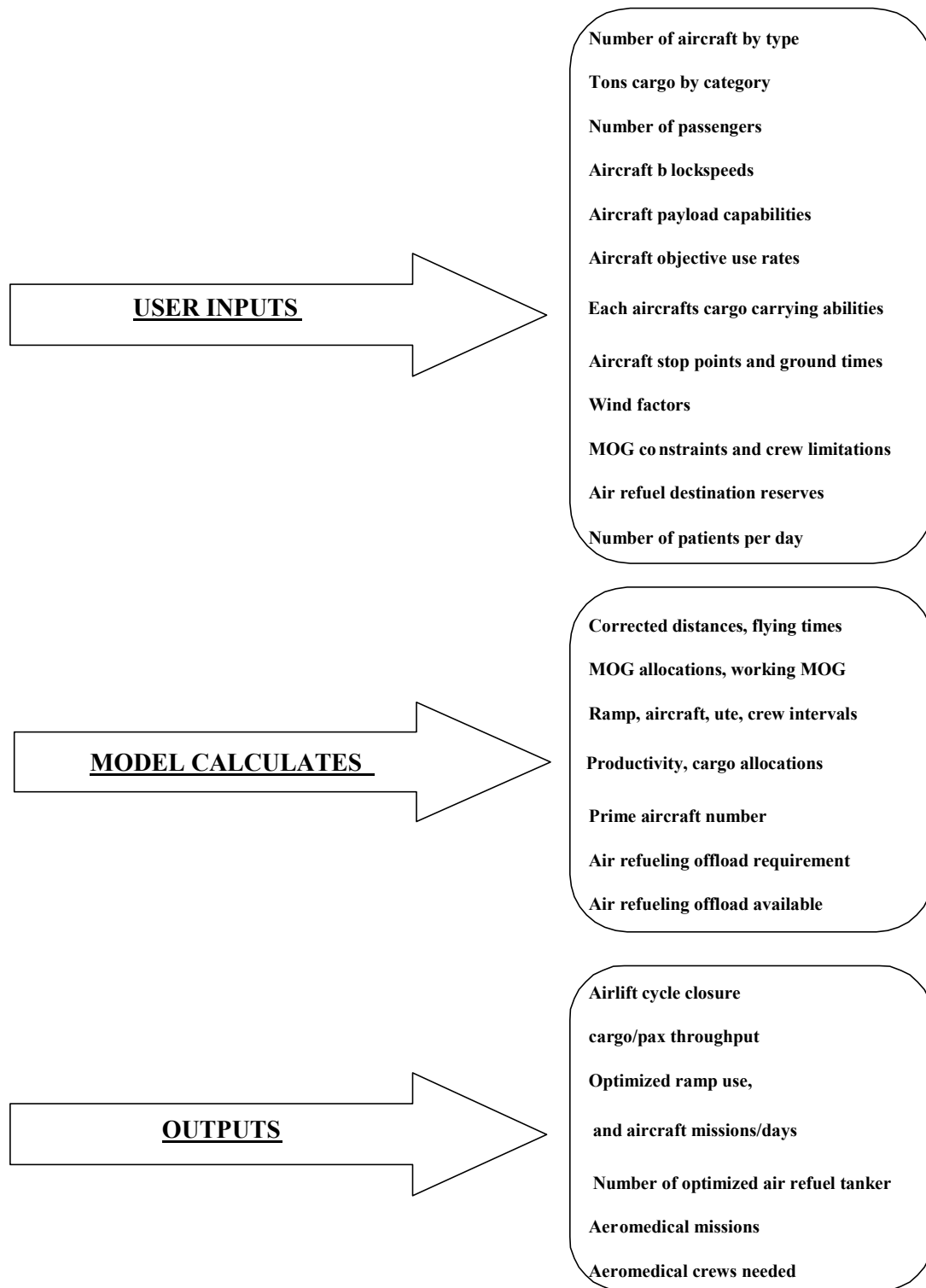


Figure 3-2. Mobility System In AMPCALC

Tanker Optimization

The model uses integer programming optimization to determine the optimum number of tankers by type for the calculated offload requirement. Microsoft Excel Solver is used to solve the integer programming problem. Below is the problem formulation:

Parameter Definitions

C_1 = operational cost of KC-135E tanker aircraft (A/C)

C_2 = operational cost of KC-135R/T tanker aircraft (A/C)

C_3 = operational cost of KC-10 tanker aircraft (A/C)

O_1 = available offload of KC-135E tanker aircraft (A/C)

O_2 = available offload of KC-135R/T tanker aircraft (A/C)

O_3 = available offload of KC-10 tanker aircraft (A/C)

TOR = total offload requirement

m_1 = maximum number of KC-135E aircraft available

m_2 = maximum number of KC-135R/T aircraft available

m_3 = maximum number of KC-10 aircraft available

Variable Definitions

X_1 = number of KC-135E tanker A/C that are used

X_2 = number of KC-135R/T tanker A/C that are used

X_3 = number of KC-10 tanker A/C that are used

Formulation

Minimize $C_1 X_1 + C_2 X_2 + C_3 X_3$

Subject to:

$$\begin{aligned}X_1 &\leq m_1 \\X_2 &\leq m_2 \\X_3 &\leq m_3 \\O_1X_1 + O_2X_2 + O_3X_3 &\geq \text{TOR} \\X_1, X_2, X_3 &\geq 0 \text{ and integer}\end{aligned}$$

Ramp Use Optimization

The model optimizes the use of ramp space. This is important as different aircraft types share ramp space and each aircraft type has its own space requirements. In this optimization, the minimum of the cargo throughput bounds, which are the ratios of allocated cargo types over cargo requirements; and the passenger throughput bound, which is the ratio of allocated passenger number over passenger requirement are maximized subject to some constraints. Although allocated and requirement cargo and passenger values are in different units, short tons and passenger, the ratios do not have any unit value. So, during calculations we consider as if these two represent the same type of quantity.

The constraints in ramp use optimization are: the total number of flight hours flown by aircraft i per day should be less than or equal to the maximum number of flight hours flown by aircraft i per day, the sum of ramp share percentages of each aircraft should be less than or equal to one hundred percent, allocated cargo throughputs should be less than or equal to each aircraft's cargo carrying abilities, allocated passenger throughput should be less than or equal to each aircraft's passenger carrying abilities.

Cargo categories are calculated as cumulative values in the model. For example, the bulk cargo value includes all three categories of cargo. Oversize cargo also includes the amount of outsize cargo. Below is the problem formulation:

Parameter Definitions

C_{ij} = maximum amount of cargo category j on aircraft i

For $i = 1, 2, 3, 4, \dots, 15$

$j = 1, 2, 3,$ and 4 (represents load types including three cargo categories, outsize cargo, oversize cargo, bulk cargo in short tons and passengers, respectively)

O_t = Total outsize cargo requirement in the model in short tons

O_v = Total oversize cargo requirement in the model in short tons

B_k = Total bulk cargo requirement in the model in short tons

P_x = Total passenger requirement in the model

M_i = maximum number of flight hours flown by aircraft i per day

OW_i = One-way interval for the aircraft i

GT_i = constrained ground time of aircraft i

MOG_i = maximum serviceable number of aircraft i

Variable Definitions

X_{ij} = Short tons of category j cargo or number of passenger carried by aircraft i per day

For $i = 1, 2, 3, 4, \dots, 15$ $j = 1, 2, 3,$ and 4

Y_i = total number of flight hours flown by aircraft i per day

$$K = \left(\sum_{i=1}^{15} X_{i1} / Ot \right) \text{ total outsized cargo carried over outsize cargo}$$

requirement

$$Q = \left(\sum_{i=1}^{15} X_{i2} / Ov \right) \text{ total oversized cargo carried over oversize cargo}$$

requirement

$$R = \left(\sum_{i=1}^{15} X_{i3} / Bk \right) \text{ total bulk cargo carried over bulk cargo requirement}$$

$$T = \left(\sum_{i=1}^{15} X_{i4} / Px \right) \text{ total number of passengers over passenger requirement}$$

$$V = \min (K, Q, R, T) \text{ minimum carrying ratio (shows the slowest flow)}$$

$$L_i = \sum_{i=1}^{15} Y_i \times GT_i / (24 \times MOG_i) \text{ ramp share of aircraft } i \text{ per day}$$

$$CLS = [(1 / V) + \max (OW_i)] \text{ (closure, day)}$$

$$CT = \sum_{i=1}^{15} X_{i3} \text{ (total cargo throughput value, short tons/day)}$$

$$PT = \sum_{i=1}^{15} X_{i4} \text{ (total passenger throughput value, pax/day)}$$

Formulation

Maximize 50 V

Subject to:

$$\sum_{i=1}^{15} L_i \leq 100 \text{ (total ramp share per day of all aircraft}$$

is at most %100 percentage)

$X_{ij} - C_{ij} \leq 0$ (each type of load to be carried cannot
exceed load carrying capability of that type $\forall i,j$)

$Y_i - M_i \leq 0$ (each type of aircraft's mission per day
cannot exceed its maximum mission value per day $\forall i$)

All variables are nonnegative.

As it can be seen in the variable definitions, the variable V represents the minimum of the cargo and passenger carrying ratios. Cargo carrying ratios, K , Q , and R represent the total cargo category carried over cargo category requirement ratios. The ratio of number of passengers carried over passenger requirement is represented by the variable T . In our mobility model, the objective is to maximize these four ratios. However, the lowest of these four determines the closure time. So, we need to maximize the minimum of those. Thus, the maximization of the minimum ratio V , in the objective function, decreases the closure value and increases the cargo/pax throughput value.

In Chapter 4, an experimental design is performed while evaluating the model's output values. Since AMPCALC is a deterministic model, the standard statistical tests such as lack of fit test cannot be applied in a statistical manner, instead R^2 value is examined for the curvature and estimated regression parameters are observed for their effects on the closure time.

IV. Analysis and Conclusion

Introduction

Chapter 4 presents the sensitivity analyses of AMPCALC with a given scenario and examines the effects of the various aircraft allocations and model factors to the model's outputs.

Sensitivity Analysis for AMPCALC

In the sensitivity analyses of the mobility system we modeled, we wanted to determine which aircraft allocation inputs have the greatest effect on the model output. To accomplish this, we designed an experiment. In the first step of sensitivity analysis, six major aircraft types of the model are chosen. These are C-5, C-141, C-17, KC-10, DC-10, and Wide Body Pax Equivalent (WB Pax) aircrafts. These aircraft types are believed to have important effects on the mobility process. Two allocation levels are assigned for each of these aircrafts, low and high. Low and high aircraft levels are plus and minus 20 of those given in the original scenario. Table 4-1 shows the low and high aircraft levels that will be used in the trials. Thus, a 2^6 full factorial design with 6 center point runs is performed under fixed scenario conditions. If we remember from chapter 2, multiple numbers of center point rows represent the relative weight of each factor in the model.

Factorial designs are widely used in experiments involving several factors where it is necessary to investigate the joint effects, including main effects and interactions, of the input factors on the outputs (Myers and Montgomery, 1995: 79). The following information details the fixed AMPCALC parameters (see Appendix C for input factor

explanations and Appendix D for AMPCALC screens) used during the experimental runs:

Cargo Requirements	Available Aircraft Numbers
4698 tons outsize	40 C-5's
12691.8 tons oversize	40 C-141's
8530.7 tons bulk	40 C-17's
35681 passengers	30 KC-10
	30 DC-10
	30 Wide Body Passengers

Cycle Stop Points

Charleston → Mildenhall → King Abdul Aziz (Naval) → Mildenhall → Charleston
 (onload) (enroute) (offload) (enroute) (onload)

Factors for AMPCALC

MC Rate Factor:	0	Controlling MOG is at offload location
Use Rate Factor:	0	49 narrow body / 24 wide body aircraft
Payload Factor:	1	Narrow body: 49
Ground Time Factor:	0	Wide body: 24
Block Speed Factor:	1	In/Out Factor (MOG Visited): 1
Crew Limit Factor:	1	
Call Up Factor:	100%	
% Augment Factor:	0%	
Waiver Factor:	0	

30/90 Day Limit Factor: 150/400

Routing Parameters

	Distance	Wind	Stop	Stage
Charleston		0	0	0
Mildenhall	3508.35	30	2	1
King Abdul Aziz (Naval)	2698.10	30	3	1
Mildenhall	2698.10	25	2	1
Charleston	3508.35	-30	1	1

In the first phase of the sensitivity analysis, cargo aircraft are not allowed to carry both passengers and cargo. In Table 4-2 allowable aircraft cargo categories and passenger percentages are presented. Table 4-3 shows each aircraft's allowable aircraft passenger carrying capacities.

Given the above scenario and a 2^6 factorial design, 64 trials plus 6 center points are run. Table 4-4 shows the cargo, pax and maximum closure times taken from the 70 trials when passenger carrying by cargo aircraft is not allowed. In Figure 4-1, the charts illustrate the chosen aircraft's low and high input factor effects on maximum closure during trials. Aircraft numbers are represented on the upper chart as divisions of each bar, related to the each trial. Closure time, for each trial, is shown on the lower chart.

Table 4-1. Aircraft Input Factors

FACTOR	GIVEN		
	LOW	VALUE	HIGH
C-5	20	40	60
C-141	20	40	60
C-17	20	40	60
KC-10	10	30	50
DC-10	10	30	50
WBP	10	30	50

Table 4-2. Allowable Aircraft Cargo and Passenger Carrying Percentages

	Outsize Cargo	Oversize Cargo	Bulk Cargo	Pax
KC-135	0%	0%	100%	100%
C-5	40%	80%	100%	100%
C-141	0%	80%	100%	100%
C-17	40%	80%	100%	100%
KC-10	0%	40%	100%	100%
DC-10	0%	0%	100%	100%
B-747F	0%	0%	100%	100%
MD-11F	0%	0%	100%	100%
WBPax	0%	0%	100%	100%
WBCargo	0%	0%	100%	100%
NBC	0%	0%	100%	100%

Table 4-3. Allowable Aircraft Passenger Carrying Capacities

	Number of Passengers with Cargo	Number of Passengers without
KC-135	0	46
C-5	51	51
C-141	11	120
C-17	11	90
KC-10	0	68
DC-10	0	180
B-747F	0	335
MD-11F	0	315
WBPax	0	335
WBCargo	0	0
NBC	0	0

Table 4-4. 2⁶ Factorial Design for Some Aircraft Allocation Values (1)

(If passenger carrying by cargo aircraft is not allowed)

TRIALS	C-5	C-141	C-17	KC-10	DC-10	WBP	CARGO CLOSURE	PAX CLOSURE	MAX CLOSURE
1	20	20	20	10	10	10	19.1	29.13	29.13
2	20	20	20	10	10	50	19.1	6.57	19.1
3	20	20	20	10	50	10	12.2	29.13	29.13
4	20	20	20	10	50	50	12.2	6.57	12.2
5	20	20	20	50	10	10	15.81	29.13	29.13
6	20	20	20	50	10	50	15.81	6.57	15.81
7	20	20	20	50	50	10	10.78	29.13	29.13
8	20	20	20	50	50	50	10.78	6.57	10.78
9	20	20	60	10	10	10	13.08	29.13	29.13
10	20	20	60	10	10	50	13.08	6.57	13.08
11	20	20	60	10	50	10	9.45	29.13	29.13
12	20	20	60	10	50	50	9.45	6.57	9.45
13	20	20	60	50	10	10	11.54	29.13	29.13
14	20	20	60	50	10	50	11.54	6.57	11.54
15	20	20	60	50	50	10	8.67	29.13	29.13
16	20	20	60	50	50	50	8.67	6.57	8.67
17	20	60	20	10	10	10	17.74	29.13	29.13
18	20	60	20	10	10	50	17.74	6.57	17.74
19	20	60	20	10	50	10	11.51	29.13	29.13
20	20	60	20	10	50	50	11.51	6.57	11.51

21	20	60	20	50	10	10	14.89	29.13	29.13
22	20	60	20	50	10	50	14.89	6.57	14.89
23	20	60	20	50	50	10	10.31	29.13	29.13
24	20	60	20	50	50	50	10.31	6.57	10.31
25	20	60	60	10	10	10	12.46	29.13	29.13
26	20	60	60	10	10	50	12.46	6.57	12.46
27	20	60	60	10	50	10	9.14	29.13	29.13
28	20	60	60	10	50	50	9.19	6.57	9.19
29	20	60	60	50	10	10	11.07	29.13	29.13
30	20	60	60	50	10	50	11.07	6.57	11.07
31	20	60	60	50	50	10	8.41	29.13	29.13
32	20	60	60	50	50	50	8.76	7.4	8.76
33	60	20	20	10	10	10	13.18	29.13	29.13
34	60	20	20	10	10	50	13.18	6.57	13.18
35	60	20	20	10	50	10	9.52	29.13	29.13
36	60	20	20	10	50	50	9.52	6.57	9.52
37	60	20	20	50	10	10	11.57	29.13	29.13
38	60	20	20	50	10	50	11.57	6.57	11.57
39	60	20	20	50	50	10	8.7	29.13	29.13
40	60	20	20	50	50	50	8.7	6.57	8.7
41	60	20	60	10	10	10	10.15	29.13	29.13
42	60	20	60	10	10	50	10.15	6.57	10.15
43	60	20	60	10	50	10	7.92	29.13	29.13
44	60	20	60	10	50	50	7.97	6.65	7.97
45	60	20	60	50	10	10	9.21	29.13	29.13
46	60	20	60	50	10	50	9.21	6.57	9.21
47	60	20	60	50	50	10	7.36	29.13	29.13
48	60	20	60	50	50	50	7.8	7.92	7.92
49	60	60	20	10	10	10	12.56	29.13	29.13
50	60	60	20	10	10	50	12.56	6.57	12.56
51	60	60	20	10	50	10	9.21	29.13	29.13
52	60	60	20	10	50	50	9.25	6.57	9.25
53	60	60	20	50	10	10	11.1	29.13	29.13
54	60	60	20	50	10	50	11.1	6.57	11.1
55	60	60	20	50	50	10	8.44	29.13	29.13
56	60	60	20	50	50	50	8.64	7.28	8.64
57	60	60	60	10	10	10	9.29	29.13	29.13
58	60	60	60	10	10	50	9.85	6.57	9.85
59	60	60	60	10	50	10	7.74	29.13	29.13
60	60	60	60	10	50	50	8.02	7.51	8.02
61	60	60	60	50	10	10	8.92	29.13	29.13
62	60	60	60	50	10	50	8.98	7.45	8.98
63	60	60	60	50	50	10	7.37	33.59	33.59
64	60	60	60	50	50	50	8.04	8.78	8.78
65	40	40	40	30	30	30	9.1	10.33	10.33
66	40	40	40	30	30	30	9.1	10.33	10.33
67	40	40	40	30	30	30	9.1	10.33	10.33
68	40	40	40	30	30	30	9.1	10.33	10.33
69	40	40	40	30	30	30	9.1	10.33	10.33
70	40	40	40	30	30	30	9.1	10.33	10.33

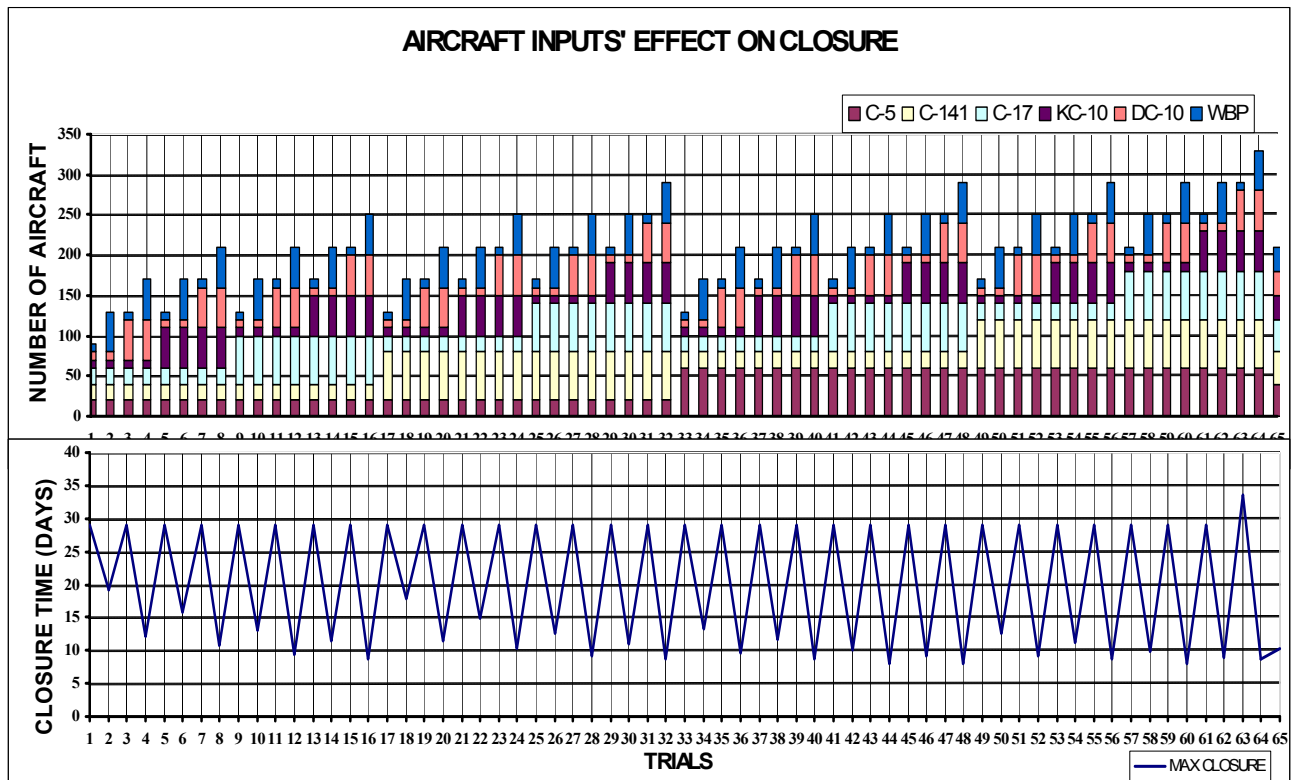


Figure 4-1. Chart of Aircraft Input Factors' Effect on Closure (1)

For the first phase of sensitivity analysis, when we examine Table 4-4 and Figure 4-1, it clearly shows that passenger closure time is determined by the WBPax aircraft. This is correct in all 70 trials. If we decrease the WBPax number, passenger closure of the system is considerably increased and vice versa. DC-10, C-17 and C-5 aircrafts have also effect on cargo closure time.

Table 4-5. Estimated Parameters For 2⁶ Factorial Design (1)

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	36.806996	5.196323	7.08	0.0004
C-5	-0.028672	0.05859	-0.49	0.6420
C-141	-0.001	0.05859	-0.02	0.9869
(C-5-40)*(C-141-40)	0.0003172	0.00293	0.11	0.9173
C-17	-0.029141	0.05859	-0.50	0.6366
(C-5-40)*(C-17-40)	0.0007398	0.00293	0.25	0.8090
(C-141-40)*(C-17-40)	0.0003297	0.00293	0.11	0.9141
(C-5-40)*(C-141-40)*(C-17-40)	0.000008	0.000146	0.05	0.9584
KC-10	-0.010969	0.05859	-0.19	0.8577
(C-5-40)*(KC-10-30)	0.0004594	0.00293	0.16	0.8805
(C-141-40)*(KC-10-30)	0.000268	0.00293	0.09	0.9301
(C-5-40)*(C-141-40)*(KC-10-30)	0.0000089	0.000146	0.06	0.9537
(C-17-40)*(KC-10-30)	0.0004875	0.00293	0.17	0.8733
(C-5-40)*(C-17-40)*(KC-10-30)	0.0000063	0.000146	0.04	0.9669
(C-141-40)*(C-17-40)*(KC-10-30)	0.0000094	0.000146	0.06	0.9508
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)	5.0195e-7	0.000007	0.07	0.9476
DC-10	-0.037625	0.05859	-0.64	0.5445
(C-5-40)*(DC-10-30)	0.0008391	0.00293	0.29	0.7842
(C-141-40)*(DC-10-30)	0.0003398	0.00293	0.12	0.9114
(C-5-40)*(C-141-40)*(DC-10-30)	0.000009	0.000146	0.06	0.9529
(C-17-40)*(DC-10-30)	0.0008563	0.00293	0.29	0.7799
(C-5-40)*(C-17-40)*(DC-10-30)	0.0000012	0.000146	0.01	0.9939
(C-141-40)*(C-17-40)*(DC-10-30)	0.0000096	0.000146	0.07	0.9496
(C-5-40)*(C-141-40)*(C-17-40)*(DC-10-30)	5.2148e-7	0.000007	0.07	0.9455
(KC-10-30)*(DC-10-30)	0.0005414	0.00293	0.18	0.8595
(C-5-40)*(KC-10-30)*(DC-10-30)	0.0000066	0.000146	0.05	0.9655
(C-141-40)*(KC-10-30)*(DC-10-30)	0.0000102	0.000146	0.07	0.9466
(C-5-40)*(C-141-40)*(KC-10-30)*(DC-10-30)	5.1562e-7	0.000007	0.07	0.9462
(C-17-40)*(KC-10-30)*(DC-10-30)	0.0000069	0.000146	0.05	0.9639
(C-5-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	6.9727e-7	0.000007	0.10	0.9273
(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	5.4297e-7	0.000007	0.07	0.9433
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	2.3047e-8	3.662e-7	0.06	0.9519
WBPax	-0.456766	0.05859	-7.80	0.0002
(C-5-40)*(WBPax-30)	-0.001782	0.00293	-0.61	0.5653
(C-141-40)*(WBPax-30)	-0.000398	0.00293	-0.14	0.8963
(C-5-40)*(C-141-40)*(WBPax-30)	-0.000002	0.000146	-0.01	0.9918
(C-17-40)*(WBPax-30)	-0.001805	0.00293	-0.62	0.5603
(C-5-40)*(C-17-40)*(WBPax-30)	0.0000196	0.000146	0.13	0.8981
(C-141-40)*(C-17-40)*(WBPax-30)	-9.375e-7	0.000146	-0.01	0.9951
(C-5-40)*(C-141-40)*(C-17-40)*(WBPax-30)	-4.727e-7	0.000007	-0.06	0.9506
(KC-10-30)*(WBPax-30)	-0.000897	0.00293	-0.31	0.7698
(C-5-40)*(KC-10-30)*(WBPax-30)	0.0000055	0.000146	0.04	0.9710
(C-141-40)*(KC-10-30)*(WBPax-30)	-0.000004	0.000146	-0.03	0.9790
(C-5-40)*(C-141-40)*(KC-10-30)*(WBPax-30)	-4.277e-7	0.000007	-0.06	0.9553
(C-17-40)*(KC-10-30)*(WBPax-30)	0.000007	0.000146	0.05	0.9637
(C-5-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-5.547e-7	0.000007	-0.08	0.9421
(C-141-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-4.004e-7	0.000007	-0.05	0.9582
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-1.846e-8	3.662e-7	-0.05	0.9614
(DC-10-30)*(WBPax-30)	-0.00223	0.00293	-0.76	0.4754
(C-5-40)*(DC-10-30)*(WBPax-30)	0.0000245	0.000146	0.17	0.8725
(C-141-40)*(DC-10-30)*(WBPax-30)	-4.297e-7	0.000146	-0.00	0.9978
(C-5-40)*(C-141-40)*(DC-10-30)*(WBPax-30)	-4.199e-7	0.000007	-0.06	0.9561
(C-17-40)*(DC-10-30)*(WBPax-30)	0.0000254	0.000146	0.17	0.8681
(C-5-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-8.125e-7	0.000007	-0.11	0.9153
(C-141-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-3.887e-7	0.000007	-0.05	0.9594
(C-5-40)*(C-141-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-1.748e-8	3.662e-7	-0.05	0.9635
(KC-10-30)*(DC-10-30)*(WBPax-30)	0.0000096	0.000146	0.07	0.9496
(C-5-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-5.41e-7	0.000007	-0.07	0.9435
(C-141-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-3.594e-7	0.000007	-0.05	0.9625
(C-5-40)*(C-141-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-1.777e-8	3.662e-7	-0.05	0.9629
(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-5.254e-7	0.000007	-0.07	0.9451
(C-5-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-8.691e-9	3.662e-7	-0.02	0.9818
(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-1.641e-8	3.662e-7	-0.04	0.9657
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-1.025e-9	1.831e-8	-0.06	0.9572

Scaled Estimates

Continuous factors centered by mean, scaled by range/2

Term	Scaled Estimate	Std Error	t Ratio	Prob> t
Intercept	19.293714	1.120464	17.22	<.0001
C-5	-0.573438	1.17181	-0.49	0.6420
C-141	-0.02	1.17181	-0.02	0.9869
(C-5-40)*(C-141-40)	0.126875	1.17181	0.11	0.9173
C-17	-0.582813	1.17181	-0.50	0.6366
(C-5-40)*(C-17-40)	0.2959375	1.17181	0.25	0.8090
(C-141-40)*(C-17-40)	0.131875	1.17181	0.11	0.9141
(C-5-40)*(C-141-40)*(C-17-40)	0.06375	1.17181	0.05	0.9584
KC-10	-0.219375	1.17181	-0.19	0.8577
(C-5-40)*(KC-10-30)	0.18375	1.17181	0.16	0.8805
(C-141-40)*(KC-10-30)	0.1071875	1.17181	0.09	0.9301
(C-5-40)*(C-141-40)*(KC-10-30)	0.0709375	1.17181	0.06	0.9537
(C-17-40)*(KC-10-30)	0.195	1.17181	0.17	0.8733
(C-5-40)*(C-17-40)*(KC-10-30)	0.050625	1.17181	0.04	0.9669
(C-141-40)*(C-17-40)*(KC-10-30)	0.0753125	1.17181	0.06	0.9508
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)	0.0803125	1.17181	0.07	0.9476
DC-10	-0.7525	1.17181	-0.64	0.5445
(C-5-40)*(DC-10-30)	0.335625	1.17181	0.29	0.7842
(C-141-40)*(DC-10-30)	0.1359375	1.17181	0.12	0.9114
(C-5-40)*(C-141-40)*(DC-10-30)	0.0721875	1.17181	0.06	0.9529
(C-17-40)*(DC-10-30)	0.3425	1.17181	0.29	0.7799
(C-5-40)*(C-17-40)*(DC-10-30)	0.009375	1.17181	0.01	0.9939
(C-141-40)*(C-17-40)*(DC-10-30)	0.0771875	1.17181	0.07	0.9496
(C-5-40)*(C-141-40)*(C-17-40)*(DC-10-30)	0.0834375	1.17181	0.07	0.9455
(KC-10-30)*(DC-10-30)	0.2165625	1.17181	0.18	0.8595
(C-5-40)*(KC-10-30)*(DC-10-30)	0.0528125	1.17181	0.05	0.9655
(C-141-40)*(KC-10-30)*(DC-10-30)	0.081875	1.17181	0.07	0.9466
(C-5-40)*(C-141-40)*(KC-10-30)*(DC-10-30)	0.0825	1.17181	0.07	0.9462
(C-17-40)*(KC-10-30)*(DC-10-30)	0.0553125	1.17181	0.05	0.9639
(C-5-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	0.1115625	1.17181	0.10	0.9273
(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	0.086875	1.17181	0.07	0.9433
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	0.07375	1.17181	0.06	0.9519
WBPax	-9.135313	1.17181	-7.80	0.0002
(C-5-40)*(WBPax-30)	-0.712812	1.17181	-0.61	0.5653
(C-141-40)*(WBPax-30)	-0.159375	1.17181	-0.14	0.8963
(C-5-40)*(C-141-40)*(WBPax-30)	-0.0125	1.17181	-0.01	0.9918
(C-17-40)*(WBPax-30)	-0.722187	1.17181	-0.62	0.5603
(C-5-40)*(C-17-40)*(WBPax-30)	0.1565625	1.17181	0.13	0.8981
(C-141-40)*(C-17-40)*(WBPax-30)	-0.0075	1.17181	-0.01	0.9951
(C-5-40)*(C-141-40)*(C-17-40)*(WBPax-30)	-0.075625	1.17181	-0.06	0.9506
(KC-10-30)*(WBPax-30)	-0.35875	1.17181	-0.31	0.7698
(C-5-40)*(KC-10-30)*(WBPax-30)	0.044375	1.17181	0.04	0.9710
(C-141-40)*(KC-10-30)*(WBPax-30)	-0.032188	1.17181	-0.03	0.9790
(C-5-40)*(C-141-40)*(KC-10-30)*(WBPax-30)	-0.068438	1.17181	-0.06	0.9553
(C-17-40)*(KC-10-30)*(WBPax-30)	0.055625	1.17181	0.05	0.9637
(C-5-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-0.08875	1.17181	-0.08	0.9421
(C-141-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-0.064063	1.17181	-0.05	0.9582
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-0.059063	1.17181	-0.05	0.9614
(DC-10-30)*(WBPax-30)	-0.891875	1.17181	-0.76	0.4754
(C-5-40)*(DC-10-30)*(WBPax-30)	0.19625	1.17181	0.17	0.8725
(C-141-40)*(DC-10-30)*(WBPax-30)	-0.003438	1.17181	-0.00	0.9978
(C-5-40)*(C-141-40)*(DC-10-30)*(WBPax-30)	-0.067188	1.17181	-0.06	0.9561
(C-17-40)*(DC-10-30)*(WBPax-30)	0.203125	1.17181	0.17	0.8681
(C-5-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-0.13	1.17181	-0.11	0.9153
(C-141-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-0.062188	1.17181	-0.05	0.9594
(C-5-40)*(C-141-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-0.055938	1.17181	-0.05	0.9635
(KC-10-30)*(DC-10-30)*(WBPax-30)	0.0771875	1.17181	0.07	0.9496
(C-5-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.086563	1.17181	-0.07	0.9435
(C-141-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.0575	1.17181	-0.05	0.9625
(C-5-40)*(C-141-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.056875	1.17181	-0.05	0.9629
(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.084063	1.17181	-0.07	0.9451
(C-5-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.027812	1.17181	-0.02	0.9818
(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.0525	1.17181	-0.04	0.9657
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.065625	1.17181	-0.06	0.9572

Summary of Fit

RSquare	0.913947
RSquare Adj	0.010392
Root Mean Square Error	9.374477
Mean of Response	19.29371
Observations (or Sum Wgts)	70

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	63	5600.1707	88.8916	1.0115
Error	6	527.2849	87.8808	Prob > F
C. Total	69	6127.4556		0.5593

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	1	527.28489	527.285	.
Pure Error	5	0.00000	0.000	Prob > F
Total Error	6	527.28489		.
				Max RSq
				1.0000

If we consider that the maximum closure outputs of each trial are the observed data of our experiment and develop a response surface model of 6 factorial degree, which would describe the relation between closure time and the aircraft numbers. Thus, all reactions and main factors are modeled. Table 4-5 gives the estimated parameter values of the response surface model. As we see, each parameter represents the unit change in the closure time when the others are kept constant. WBPax is very effective on closure time. Table 4-5 also shows the effects of DC-10, C-17, C-5 and their two term interactions with WBPax on closure time. The center point rows for each factor, here 6 rows for 6 factors, affects only the intercept term in the regression equation. They help to identify the curvature in the model. Since the model is deterministic, when all the interactions are represented in the model, no pure error is seen, but the lack of fit (see end of Table 4-5). The lack of fit is the indicator of curvature in the model. As it is explained in chapter 2, as the R^2 value decreases, more curvature is observed in the system.

Table 4-6. 2⁶ Factorial Design for Some Aircraft Allocation Values (2)

(If passenger carrying is allowed to the cargo aircrafts)

TRIALS	C-5	C-141	C-17	KC-10	DC-10	WBP	CARGO CLOSURE	PAX CLOSURE	MAX CLOSURE
1	20	20	20	10	10	10	19.1	20.93	20.93
2	20	20	20	10	10	50	19.1	4.93	19.1
3	20	20	20	10	50	10	12.2	24.04	24.04
4	20	20	20	10	50	50	12.2	5.55	12.2
5	20	20	20	50	10	10	15.81	22.4	22.4
6	20	20	20	50	10	50	15.81	5.23	15.81
7	20	20	20	50	50	10	10.78	24.68	24.68
8	20	20	20	50	50	50	10.78	5.68	10.78
9	20	20	60	10	10	10	13.08	21.97	21.97
10	20	20	60	10	10	50	13.08	5.14	13.08
11	20	20	60	10	50	10	9.45	24.11	24.11
12	20	20	60	10	50	50	9.45	5.57	9.45
13	20	20	60	50	10	10	11.54	22.91	22.91
14	20	20	60	50	10	50	11.54	5.33	11.54
15	20	20	60	50	50	10	8.67	24.6	24.6
16	20	20	60	50	50	50	8.67	5.67	8.67
17	20	60	20	10	10	10	17.74	20.64	20.64
18	20	60	20	10	10	50	17.74	4.87	17.74
19	20	60	20	10	50	10	11.51	23.8	23.8
20	20	60	20	10	50	50	11.51	5.5	11.51
21	20	60	20	50	10	10	14.89	22.12	22.12
22	20	60	20	50	10	50	14.89	5.17	14.89
23	20	60	20	50	50	10	10.31	24.42	24.42
24	20	60	20	50	50	50	10.31	5.63	10.31
25	20	60	60	10	10	10	12.46	21.72	21.72
26	20	60	60	10	10	50	12.46	5.09	12.46
27	20	60	60	10	50	10	9.14	23.86	23.86
28	20	60	60	10	50	50	9.19	5.51	9.19
29	20	60	60	50	10	10	11.07	22.65	22.65
30	20	60	60	50	10	50	11.07	5.27	11.07
31	20	60	60	50	50	10	8.41	24.35	24.35
32	20	60	60	50	50	50	8.76	6.31	8.76
33	60	20	20	10	10	10	13.18	17.96	17.96
34	60	20	20	10	10	50	13.18	4.34	13.18
35	60	20	20	10	50	10	9.52	21.31	21.31
36	60	20	20	10	50	50	9.52	5.01	9.52
37	60	20	20	50	10	10	11.57	19.43	19.43
38	60	20	20	50	10	50	11.57	4.63	11.57
39	60	20	20	50	50	10	8.7	22.06	22.06
40	60	20	20	50	50	50	8.7	5.16	8.7
41	60	20	60	10	10	10	10.15	19.48	19.48
42	60	20	60	10	10	50	10.15	4.64	10.15
43	60	20	60	10	50	10	7.92	21.83	21.83
44	60	20	60	10	50	50	7.97	5.16	7.97
45	60	20	60	50	10	10	9.21	20.47	20.47
46	60	20	60	50	10	50	9.21	4.84	9.21
47	60	20	60	50	50	10	7.36	22.41	22.41
48	60	20	60	50	50	50	7.8	6.19	7.8
49	60	60	20	10	10	10	12.56	17.91	17.91
50	60	60	20	10	10	50	12.56	4.33	12.56

51	60	60	20	10	50	10	9.21	21.16	21.16
52	60	60	20	10	50	50	9.25	4.97	9.25
53	60	60	20	50	10	10	11.1	19.33	19.33
54	60	60	20	50	10	50	11.1	4.61	11.1
55	60	60	20	50	50	10	8.44	21.9	21.9
56	60	60	20	50	50	50	8.64	5.61	8.64
57	60	60	60	10	10	10	9.79	19.39	19.39
58	60	60	60	10	10	50	9.85	4.61	9.85
59	60	60	60	10	50	10	7.74	21.65	21.65
60	60	60	60	10	50	50	8.02	5.69	8.02
61	60	60	60	50	10	10	8.92	20.35	20.35
62	60	60	60	50	10	50	8.98	5.4	8.98
63	60	60	60	50	50	10	7.37	25.41	25.41
64	60	60	60	50	50	50	8.04	6.82	8.04
65	40	40	40	30	30	30	9.1	7.93	9.1
66	40	40	40	30	30	30	9.1	7.93	9.1
67	40	40	40	30	30	30	9.1	7.93	9.1
68	40	40	40	30	30	30	9.1	7.93	9.1
69	40	40	40	30	30	30	9.1	7.93	9.1
70	40	40	40	30	30	30	9.1	7.93	9.1

In the second phase of the sensitivity analysis, cargo aircraft are allowed to carry passengers with cargo. Table 4-6 shows the cargo, pax and maximum closure values taken from the 70 trials when cargo aircraft carry passengers. Table 4-7 presents estimated parameter values for response surface model of factorial degree 6. Main aircraft input effects and all aircraft interaction terms on the closure time are shown in this table. WPax's effect on closure time can be easily seen in the Table 4-7. Besides, C-5, C-17, and DC-10 aircraft effects can be seen on closure time. Here, C-5 is more effective to decrease closure time than DC-10 is, since the C-5's passenger carrying ability with cargo (see Table 4-3) is added to the model. Instead, WPax aircraft significance on the closure is decreased even it is not so much. Additionally, the smaller R^2 value, shows that the curvature is more significant than the previous model's.

Table 4-7. Estimated Parameters For 2⁶ Factorial Design (2)

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	27.923181	3.891901	7.17	0.0004
C-5	-0.061852	0.043883	-1.41	0.2084
C-141	-0.004914	0.043883	-0.11	0.9145
(C-5-40)*(C-141-40)	0.000284	0.002194	0.13	0.9012
C-17	-0.023086	0.043883	-0.53	0.6177
(C-5-40)*(C-17-40)	0.0007973	0.002194	0.36	0.7288
(C-141-40)*(C-17-40)	0.0002535	0.002194	0.12	0.9118
(C-5-40)*(C-141-40)*(C-17-40)	0.0000039	0.00011	0.04	0.9726
KC-10	-0.001273	0.043883	-0.03	0.9778
(C-5-40)*(KC-10-30)	0.0003926	0.002194	0.18	0.8639
(C-141-40)*(KC-10-30)	0.0001895	0.002194	0.09	0.9340
(C-5-40)*(C-141-40)*(KC-10-30)	0.0000005	0.00011	0.05	0.9650
(C-17-40)*(KC-10-30)	0.0003012	0.002194	0.14	0.8953
(C-5-40)*(C-17-40)*(KC-10-30)	0.0000023	0.00011	0.02	0.9838
(C-141-40)*(C-17-40)*(KC-10-30)	0.0000058	0.00011	0.05	0.9598
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)	3.1934e-7	0.000005	0.06	0.9555
DC-10	-0.009023	0.043883	-0.21	0.8439
(C-5-40)*(DC-10-30)	0.0008223	0.002194	0.37	0.7207
(C-141-40)*(DC-10-30)	0.0002566	0.002194	0.12	0.9107
(C-5-40)*(C-141-40)*(DC-10-30)	0.0000046	0.00011	0.04	0.9683
(C-17-40)*(DC-10-30)	0.0005168	0.002194	0.24	0.8216
(C-5-40)*(C-17-40)*(DC-10-30)	-0.0000003	0.00011	-0.03	0.9764
(C-141-40)*(C-17-40)*(DC-10-30)	0.0000058	0.00011	0.05	0.9593
(C-5-40)*(C-141-40)*(C-17-40)*(DC-10-30)	3.4277e-7	0.000005	0.06	0.9522
(KC-10-30)*(DC-10-30)	0.0002715	0.002194	0.12	0.9056
(C-5-40)*(KC-10-30)*(DC-10-30)	0.0000032	0.00011	0.03	0.9778
(C-141-40)*(KC-10-30)*(DC-10-30)	0.0000066	0.00011	0.06	0.9538
(C-5-40)*(C-141-40)*(KC-10-30)*(DC-10-30)	3.3887e-7	0.000005	0.06	0.9527
(C-17-40)*(KC-10-30)*(DC-10-30)	0.0000055	0.00011	0.05	0.9617
(C-5-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	4.6973e-7	0.000005	0.09	0.9345
(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	3.6035e-7	0.000005	0.07	0.9498
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	1.3525e-8	2.743e-7	0.05	0.9623
WBPax	-0.273555	0.043883	-6.23	0.0008
(C-5-40)*(WBPax-30)	-0.00019	0.002194	-0.09	0.9337
(C-141-40)*(WBPax-30)	-0.000251	0.002194	-0.11	0.9126
(C-5-40)*(C-141-40)*(WBPax-30)	-0.000002	0.00011	-0.02	0.9838
(C-17-40)*(WBPax-30)	-0.002175	0.002194	-0.99	0.3597
(C-5-40)*(C-17-40)*(WBPax-30)	0.0000133	0.00011	0.12	0.9072
(C-141-40)*(C-17-40)*(WBPax-30)	4.4922e-7	0.00011	0.00	0.9969
(C-5-40)*(C-141-40)*(C-17-40)*(WBPax-30)	-3.916e-7	0.000005	-0.07	0.9454
(KC-10-30)*(WBPax-30)	-0.001449	0.002194	-0.66	0.5336
(C-5-40)*(KC-10-30)*(WBPax-30)	0.0000055	0.00011	0.05	0.9615
(C-141-40)*(KC-10-30)*(WBPax-30)	-0.000003	0.00011	-0.02	0.9824
(C-5-40)*(C-141-40)*(KC-10-30)*(WBPax-30)	-3.564e-7	0.000005	-0.06	0.9503
(C-17-40)*(KC-10-30)*(WBPax-30)	0.0000129	0.00011	0.12	0.9102
(C-5-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-5.225e-7	0.000005	-0.10	0.9272
(C-141-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-3.389e-7	0.000005	-0.06	0.9527
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-1.538e-8	2.743e-7	-0.06	0.9571
(DC-10-30)*(WBPax-30)	-0.003727	0.002194	-1.70	0.1403
(C-5-40)*(DC-10-30)*(WBPax-30)	0.000022	0.00011	0.20	0.8476
(C-141-40)*(DC-10-30)*(WBPax-30)	0.0000013	0.00011	0.01	0.9909
(C-5-40)*(C-141-40)*(DC-10-30)*(WBPax-30)	-3.174e-7	0.000005	-0.06	0.9557
(C-17-40)*(DC-10-30)*(WBPax-30)	0.000039	0.00011	0.36	0.7344
(C-5-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-7.529e-7	0.000005	-0.14	0.8953
(C-141-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-3.193e-7	0.000005	-0.06	0.9555
(C-5-40)*(C-141-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-1.46e-8	2.743e-7	-0.05	0.9593
(KC-10-30)*(DC-10-30)*(WBPax-30)	0.0000198	0.00011	0.18	0.8628
(C-5-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-5.381e-7	0.000005	-0.10	0.9251
(C-141-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-2.998e-7	0.000005	-0.05	0.9582
(C-5-40)*(C-141-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-1.499e-8	2.743e-7	-0.05	0.9582
(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-6.221e-7	0.000005	-0.11	0.9134
(C-5-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-5.713e-9	2.743e-7	-0.02	0.9841
(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-1.333e-8	2.743e-7	-0.05	0.9628
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-8.52e-10	1.371e-8	-0.06	0.9525

Scaled Estimates

Continuous factors centered by mean, scaled by range/2

Term	Scaled Estimate	Std Error	t Ratio	Prob> t
Intercept	15.813571	0.839196	18.84	<.0001
C-5	-1.237031	0.877653	-1.41	0.2084
C-141	-0.098281	0.877653	-0.11	0.9145
(C-5-40)*(C-141-40)	0.1135937	0.877653	0.13	0.9012
C-17	-0.461719	0.877653	-0.53	0.6177
(C-5-40)*(C-17-40)	0.3189062	0.877653	0.36	0.7288
(C-141-40)*(C-17-40)	0.1014062	0.877653	0.12	0.9118
(C-5-40)*(C-141-40)*(C-17-40)	0.0314062	0.877653	0.04	0.9726
KC-10	-0.025469	0.877653	-0.03	0.9778
(C-5-40)*(KC-10-30)	0.1570312	0.877653	0.18	0.8639
(C-141-40)*(KC-10-30)	0.0757812	0.877653	0.09	0.9340
(C-5-40)*(C-141-40)*(KC-10-30)	0.0401562	0.877653	0.05	0.9650
(C-17-40)*(KC-10-30)	0.1204687	0.877653	0.14	0.8953
(C-5-40)*(C-17-40)*(KC-10-30)	0.0185937	0.877653	0.02	0.9838
(C-141-40)*(C-17-40)*(KC-10-30)	0.0460937	0.877653	0.05	0.9598
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)	0.0510937	0.877653	0.06	0.9555
DC-10	-0.180469	0.877653	-0.21	0.8439
(C-5-40)*(DC-10-30)	0.3289062	0.877653	0.37	0.7207
(C-141-40)*(DC-10-30)	0.1026562	0.877653	0.12	0.9107
(C-5-40)*(C-141-40)*(DC-10-30)	0.0364062	0.877653	0.04	0.9683
(C-17-40)*(DC-10-30)	0.2067187	0.877653	0.24	0.8216
(C-5-40)*(C-17-40)*(DC-10-30)	-0.027031	0.877653	-0.03	0.9764
(C-141-40)*(C-17-40)*(DC-10-30)	0.0467187	0.877653	0.05	0.9593
(C-5-40)*(C-141-40)*(C-17-40)*(DC-10-30)	0.0548437	0.877653	0.06	0.9522
(KC-10-30)*(DC-10-30)	0.1085937	0.877653	0.12	0.9056
(C-5-40)*(KC-10-30)*(DC-10-30)	0.0254687	0.877653	0.03	0.9778
(C-141-40)*(KC-10-30)*(DC-10-30)	0.0529687	0.877653	0.06	0.9538
(C-5-40)*(C-141-40)*(KC-10-30)*(DC-10-30)	0.0542187	0.877653	0.06	0.9527
(C-17-40)*(KC-10-30)*(DC-10-30)	0.0439062	0.877653	0.05	0.9617
(C-5-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	0.0751562	0.877653	0.09	0.9345
(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	0.0576562	0.877653	0.07	0.9498
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)	0.0432812	0.877653	0.05	0.9623
WBPax	-5.471094	0.877653	-6.23	0.0008
(C-5-40)*(WBPax-30)	-0.076094	0.877653	-0.09	0.9337
(C-141-40)*(WBPax-30)	-0.100469	0.877653	-0.11	0.9126
(C-5-40)*(C-141-40)*(WBPax-30)	-0.018594	0.877653	-0.02	0.9838
(C-17-40)*(WBPax-30)	-0.870156	0.877653	-0.99	0.3597
(C-5-40)*(C-17-40)*(WBPax-30)	0.1067187	0.877653	0.12	0.9072
(C-141-40)*(C-17-40)*(WBPax-30)	0.0035937	0.877653	0.00	0.9969
(C-5-40)*(C-141-40)*(C-17-40)*(WBPax-30)	-0.062656	0.877653	-0.07	0.9454
(KC-10-30)*(WBPax-30)	-0.579531	0.877653	-0.66	0.5336
(C-5-40)*(KC-10-30)*(WBPax-30)	0.0442187	0.877653	0.05	0.9615
(C-141-40)*(KC-10-30)*(WBPax-30)	-0.020156	0.877653	-0.02	0.9824
(C-5-40)*(C-141-40)*(KC-10-30)*(WBPax-30)	-0.057031	0.877653	-0.06	0.9503
(C-17-40)*(KC-10-30)*(WBPax-30)	0.1032812	0.877653	0.12	0.9102
(C-5-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-0.083594	0.877653	-0.10	0.9272
(C-141-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-0.054219	0.877653	-0.06	0.9527
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(WBPax-30)	-0.049219	0.877653	-0.06	0.9571
(DC-10-30)*(WBPax-30)	-1.490781	0.877653	-1.70	0.1403
(C-5-40)*(DC-10-30)*(WBPax-30)	0.1760937	0.877653	0.20	0.8476
(C-141-40)*(DC-10-30)*(WBPax-30)	0.0104687	0.877653	0.01	0.9909
(C-5-40)*(C-141-40)*(DC-10-30)*(WBPax-30)	-0.050781	0.877653	-0.06	0.9557
(C-17-40)*(DC-10-30)*(WBPax-30)	0.3120312	0.877653	0.36	0.7344
(C-5-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-0.120469	0.877653	-0.14	0.8953
(C-141-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-0.051094	0.877653	-0.06	0.9555
(C-5-40)*(C-141-40)*(C-17-40)*(DC-10-30)*(WBPax-30)	-0.046719	0.877653	-0.05	0.9593
(KC-10-30)*(DC-10-30)*(WBPax-30)	0.1582812	0.877653	0.18	0.8628
(C-5-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.086094	0.877653	-0.10	0.9251
(C-141-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.047969	0.877653	-0.05	0.9582
(C-5-40)*(C-141-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.047969	0.877653	-0.05	0.9582
(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.099531	0.877653	-0.11	0.9134
(C-5-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.018281	0.877653	-0.02	0.9841
(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.042656	0.877653	-0.05	0.9628
(C-5-40)*(C-141-40)*(C-17-40)*(KC-10-30)*(DC-10-30)*(WBPax-30)	-0.054531	0.877653	-0.06	0.9525

Summary of Fit

RSquare	0.885308
RSquare Adj	-0.31896
Root Mean Square Error	7.021221
Mean of Response	15.81357
Observations (or Sum Wgts)	70

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	63	2283.1633	36.2407	0.7351
Error	6	295.7853	49.2975	Prob > F
C. Total	69	2578.9486		0.7555

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	1	295.78527	295.785	.
Pure Error	5	0.00000	0.000	Prob > F
Total Error	6	295.78527		.
				Max RSq
				1.0000

As a third phase of sensitivity analysis, AMPCALC input factors are examined. Given aircraft numbers in the scenario are fixed, 6 major AMPCALC input factors (see Appendix C for definitions) are entered as two coded input values (see Table 4-8). In this phase, no center point runs are performed and cargo aircraft are allowed to carry passengers with cargo. For each trial, cargo, passenger closure times and maximum closure times are shown in Table 4-9.

Table 4-8. AMPCALC Input Factors

FACTORS	CODED INPUT VALUES	
USE RATE	0	1
PAYLOAD	0	1
BLOCK SPEED	1	2
GROUND TIME	0	1
CREW LIMIT	0	1
IN/OUT (MOG VISITED)	0	1

Table 4-9. 2⁶ Factorial Design of AMPCALC's Input Factors

TRIALS	USE RATE	PAYLOAD	BLOCK SPD.	GRND. TM.	CREW LIM.	IN/OUT	CARGO CLOSURE	PAX CLOSURE	MAX CLOSURE
1	0	0	1	0	0	0	9.01	7.92	9.01
2	0	0	1	0	0	1	9.01	7.92	9.01
3	0	0	1	0	1	0	9.1	7.93	9.1
4	0	0	1	0	1	1	9.1	7.93	9.1
5	0	0	1	1	0	0	9.04	7.92	9.04
6	0	0	1	1	0	1	9.04	7.92	9.04
7	0	0	1	1	1	0	9.13	7.93	9.13
8	0	0	1	1	1	1	9.13	7.93	9.13
9	0	0	2	0	0	0	8.74	7.85	8.74
10	0	0	2	0	0	1	8.77	7.84	8.77
11	0	0	2	0	1	0	8.83	7.87	8.83
12	0	0	2	0	1	1	8.84	7.87	8.84
13	0	0	2	1	0	0	8.78	7.85	8.78
14	0	0	2	1	0	1	8.8	7.84	8.8
15	0	0	2	1	1	0	8.86	7.87	8.86
16	0	0	2	1	1	1	8.87	7.87	8.87
17	0	1	1	0	0	0	9.01	7.92	9.01
18	0	1	1	0	0	1	9.01	7.92	9.01
19	0	1	1	0	1	0	9.1	7.93	9.1
20	0	1	1	0	1	1	9.1	7.93	9.1
21	0	1	1	1	0	0	9.04	7.92	9.04
22	0	1	1	1	0	1	9.04	7.92	9.04
23	0	1	1	1	1	0	9.13	7.93	9.13
24	0	1	1	1	1	1	9.13	7.93	9.13
25	0	1	2	0	0	0	8.74	7.85	8.74
26	0	1	2	0	0	1	8.77	7.84	8.77
27	0	1	2	0	1	0	8.83	7.87	8.83
28	0	1	2	0	1	1	8.84	7.87	8.84
29	0	1	2	1	0	0	8.78	7.85	8.78
30	0	1	2	1	0	1	8.8	7.84	8.8
31	0	1	2	1	1	0	8.86	7.87	8.86
32	0	1	2	1	1	1	8.87	7.87	8.87
33	1	0	1	0	0	0	11.64	8.2	11.64
34	1	0	1	0	0	1	11.64	8.2	11.64
35	1	0	1	0	1	0	11.64	8.2	11.64
36	1	0	1	0	1	1	11.64	8.2	11.64
37	1	0	1	1	0	0	11.67	8.2	11.67
38	1	0	1	1	0	1	11.67	8.2	11.67
39	1	0	1	1	1	0	11.67	8.2	11.67
40	1	0	1	1	1	1	11.67	8.2	11.67
41	1	0	2	0	0	0	11.29	8.13	11.29
42	1	0	2	0	0	1	11.29	8.13	11.29
43	1	0	2	0	1	0	11.29	8.13	11.29
44	1	0	2	0	1	1	11.29	8.13	11.29
45	1	0	2	1	0	0	11.32	8.13	11.32

46	1	0	2	1	0	1	11.32	8.13	11.32
47	1	0	2	1	1	0	11.32	8.13	11.32
48	1	0	2	1	1	1	11.32	8.13	11.32
49	1	1	1	0	0	0	11.64	8.2	11.64
50	1	1	1	0	0	1	11.64	8.2	11.64
51	1	1	1	0	1	0	11.64	8.2	11.64
52	1	1	1	0	1	1	11.64	8.2	11.64
53	1	1	1	1	0	0	11.67	8.2	11.67
54	1	1	1	1	0	1	11.67	8.2	11.67
55	1	1	1	1	1	0	11.67	8.2	11.67
56	1	1	1	1	1	1	11.67	8.2	11.67
57	1	1	2	0	0	0	11.29	8.13	11.29
58	1	1	2	0	0	1	11.29	8.13	11.29
59	1	1	2	0	1	0	11.29	8.13	11.29
60	1	1	2	0	1	1	11.29	8.13	11.29
61	1	1	2	1	0	0	11.32	8.13	11.32
62	1	1	2	1	0	1	11.32	8.13	11.32
63	1	1	2	1	1	0	11.32	8.13	11.32
64	1	1	2	1	1	1	11.32	8.13	11.32

Table 4-10 shows estimated parameter values for AMPCALC factors. In the linear regression equation of the response surface model, these parameters represent AMPCALC factor coefficients and show their effect on the closure time. As it is seen in Table 4-10, more than two term-interactions are insignificant. According to the Table 4-9 and Table 4-10, just the use rate and block speed factors seem effective on decreasing the closure time. The use rate factor of 0 decreases closure time while a block speed factor of 1 increases closure time. This is because a 0 use rate factor represents the surge utilization rate which is larger than alternate utilization rate (represented by factor 1) for the non-CRAF aircraft modeled. A block speed factor of 2 represents distance related to block speed values which are larger than alternative block speed values (represented by a factor of 1) for each aircraft, so they also decrease closure time. In addition to the three full factorial designs, Appendix C shows a comparison between three cargo aircrafts, C-5, C-141, and C-17 in AMPCALC. In Appendix C, for each of 216 trials, fixed

Table 4-10. Estimated Parameters For 2⁶ Factorial Design of AMPCALC Factors

Summary of Fit				
RSquare	0.999993			
RSquare Adj	0.99999			
Root Mean Square Error	0.004082			
Mean of Response	10.21031			
Observations (or Sum Wgts)	64			
Analysis of Variance				
Source	DF	Sum of Square	Mean Square	F Ratio
Model	21	104.76269	4.98870	299322
Error	42	0.00070	0.00002	Prob > F
C. Total	63	104.76339		<.0001

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	9.35875	0.001976	4735.2	<.0001
USE RATE	2.539375	0.001021	2488.1	<.0001
PAYLOAD	-3.55e-15	0.001021	-0.00	1.0000
(USE RATE-0.5)*(PAYLOAD-0.5)	2.665e-15	0.002041	0.00	1.0000
BLOCK SPEED	-0.304375	0.001021	-298.2	<.0001
(USE RATE-0.5)*(BLOCK SPEED-1.5)	-0.09125	0.002041	-44.70	<.0001
(PAYLOAD-0.5)*(BLOCK SPEED-1.5)	8.882e-16	0.002041	0.00	1.0000
GROUND TIME	0.030625	0.001021	30.01	<.0001
(USE RATE-0.5)*(GROUND TIME-0.5)	-0.00125	0.002041	-0.61	0.5436
(PAYLOAD-0.5)*(GROUND TIME-0.5)	4.441e-16	0.002041	0.00	1.0000
(BLOCK SPEED-1.5)*(GROUND TIME-0.5)	0.00125	0.002041	0.61	0.5436
CREW LIMIT	0.041875	0.001021	41.03	<.0001
(USE RATE-0.5)*(CREW LIMIT-0.5)	-0.08375	0.002041	-41.03	<.0001
(PAYLOAD-0.5)*(CREW LIMIT-0.5)	4.441e-16	0.002041	0.00	1.0000
(BLOCK SPEED-1.5)*(CREW LIMIT-0.5)	-0.00625	0.002041	-3.06	0.0038
(GROUND TIME-0.5)*(CREW LIMIT-0.5)	-0.00125	0.002041	-0.61	0.5436
IN/OUT (MOG.VST.)	0.004375	0.001021	4.29	0.0001
(USE RATE-0.5)*(IN/OUT (MOG.VST.)-0.5)	-0.00875	0.002041	-4.29	0.0001
(PAYLOAD-0.5)*(IN/OUT (MOG.VST.)-0.5)	0	0.002041	0.00	1.0000
(BLOCK SPEED-1.5)*(IN/OUT (MOG.VST.)-0.5)	0.00875	0.002041	4.29	0.0001
(GROUND TIME-0.5)*(IN/OUT (MOG.VST.)-0.5)	-0.00125	0.002041	-0.61	0.5436
(CREW LIMIT-0.5)*(IN/OUT (MOG.VST.)-0.5)	-0.00375	0.002041	-1.84	0.0733

Scaled Estimates				
Continuous factors centered by mean, scaled by range/2				
Term	Scaled Estimate	Std Error	t Ratio	Prob> t
Intercept	10.210312	0.00051	20008.04	<.0001
USE RATE	1.2696875	0.00051	2488.07	<.0001
PAYLOAD	-1.78e-15	0.00051	-0.00	1.0000
(USE RATE-0.5)*(PAYLOAD-0.5)	6.661e-16	0.00051	0.00	1.0000
BLOCK SPEED	-0.152187	0.00051	-298.23	<.0001
(USE RATE-0.5)*(BLOCK SPEED-1.5)	-0.022813	0.00051	-44.70	<.0001
(PAYLOAD-0.5)*(BLOCK SPEED-1.5)	2.22e-16	0.00051	0.00	1.0000
GROUND TIME	0.0153125	0.00051	30.01	<.0001
(USE RATE-0.5)*(GROUND TIME-0.5)	-0.000312	0.00051	-0.61	0.5436
(PAYLOAD-0.5)*(GROUND TIME-0.5)	1.11e-16	0.00051	0.00	1.0000
(BLOCK SPEED-1.5)*(GROUND TIME-0.5)	0.0003125	0.00051	0.61	0.5436
CREW LIMIT	0.0209375	0.00051	41.03	<.0001
(USE RATE-0.5)*(CREW LIMIT-0.5)	-0.020938	0.00051	-41.03	<.0001
(PAYLOAD-0.5)*(CREW LIMIT-0.5)	1.11e-16	0.00051	0.00	1.0000
(BLOCK SPEED-1.5)*(CREW LIMIT-0.5)	-0.001563	0.00051	-3.06	0.0038
(GROUND TIME-0.5)*(CREW LIMIT-0.5)	-0.000312	0.00051	-0.61	0.5436
IN/OUT (MOG VISITED)	0.0021875	0.00051	4.29	0.0001
(USE RATE-0.5)*(IN/OUT (MOG VISITED)-0.5)	-0.002188	0.00051	-4.29	0.0001
(PAYLOAD-0.5)*(IN/OUT (MOG VISITED)-0.5)	0	0.00051	0.00	1.0000
(BLOCK SPEED-1.5)*(IN/OUT (MOG VISITED)-0.5)	0.0021875	0.00051	4.29	0.0001
(GROUND TIME-0.5)*(IN/OUT (MOG VISITED)-0.5)	-0.000312	0.00051	-0.61	0.5436
(CREW LIMIT-0.5)*(IN/OUT (MOG VISITED)-0.5)	-0.000938	0.00051	-1.84	0.0733

AMPCALC parameters given at the beginning of this chapter are considered. Then for each aircraft, from 0 to 50 aircraft allocation numbers are entered by tens. This phase of the sensitivity analysis is not a part of the response surface study. It is just the study to observe effects of six input levels for three aircraft factor combinations on closure times and throughputs. Each allocation level represents the aircraft's weight for that trial. All $6 \times 6 \times 6 = 216$ combinations are considered. Cargo and passenger closure times, daily throughput values and maximum closure times are observed as output. For this given scenario conditions, result of trials give 50 C-5, 40 C-141, and 50 C-17 for the best closure time and cargo throughput, 8.21 days and 3188.87 tons/day, respectively; however, passenger throughput of this combination is the third best of all trials which is 4522pax/day. This phase of the study also shows that (see Appendix C) as the aircraft allocation levels increases with proportional steps, closure times and throughputs do not decrease and increase with the same manner, respectively, therefore, we can say that the relation between those are not linear.

Figure 4-2 and Figure 4-3 show the relation between aircraft numbers and closure times. It is seen that there is no linear relation between aircraft numbers and closure time. We had also observed curvature in the first and second phases of sensitivity analysis models. In Figure 4-2 aircraft numbers are increased equally. First, maximum closure decreases, then, goes linear, after, goes up.

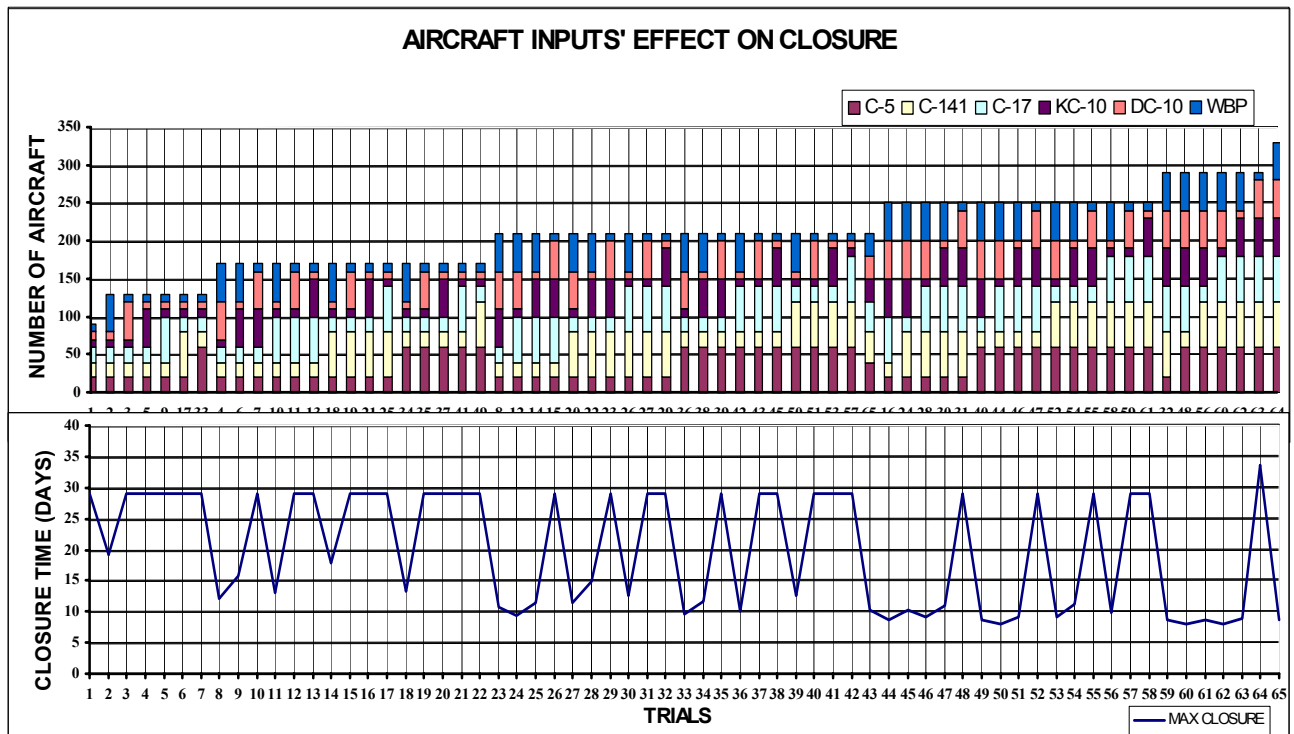


Figure 4-2. Chart of Aircraft Input Factors' Effect on Closure (2)

(Aircraft allocation numbers are in increasing order)

As we saw in the analyses, the mobility system we have modeled has many dimensions. Each input parameter to the model may have several interaction effects with other parameters. More aircraft is not a guarantee of better closure time. Even if your cargo or pax closure is very short, the maximum of those determines the final closure. Faster block speeds may seem to shorten the closure time; however, it is not always the case. Because this may decrease aircraft utilization rates and increase the flying hour capability interval which may increase the flow interval limit of the mobility system and finally may increase the closure time. Thus, the relation between the number of aircraft and closure time is not linear.

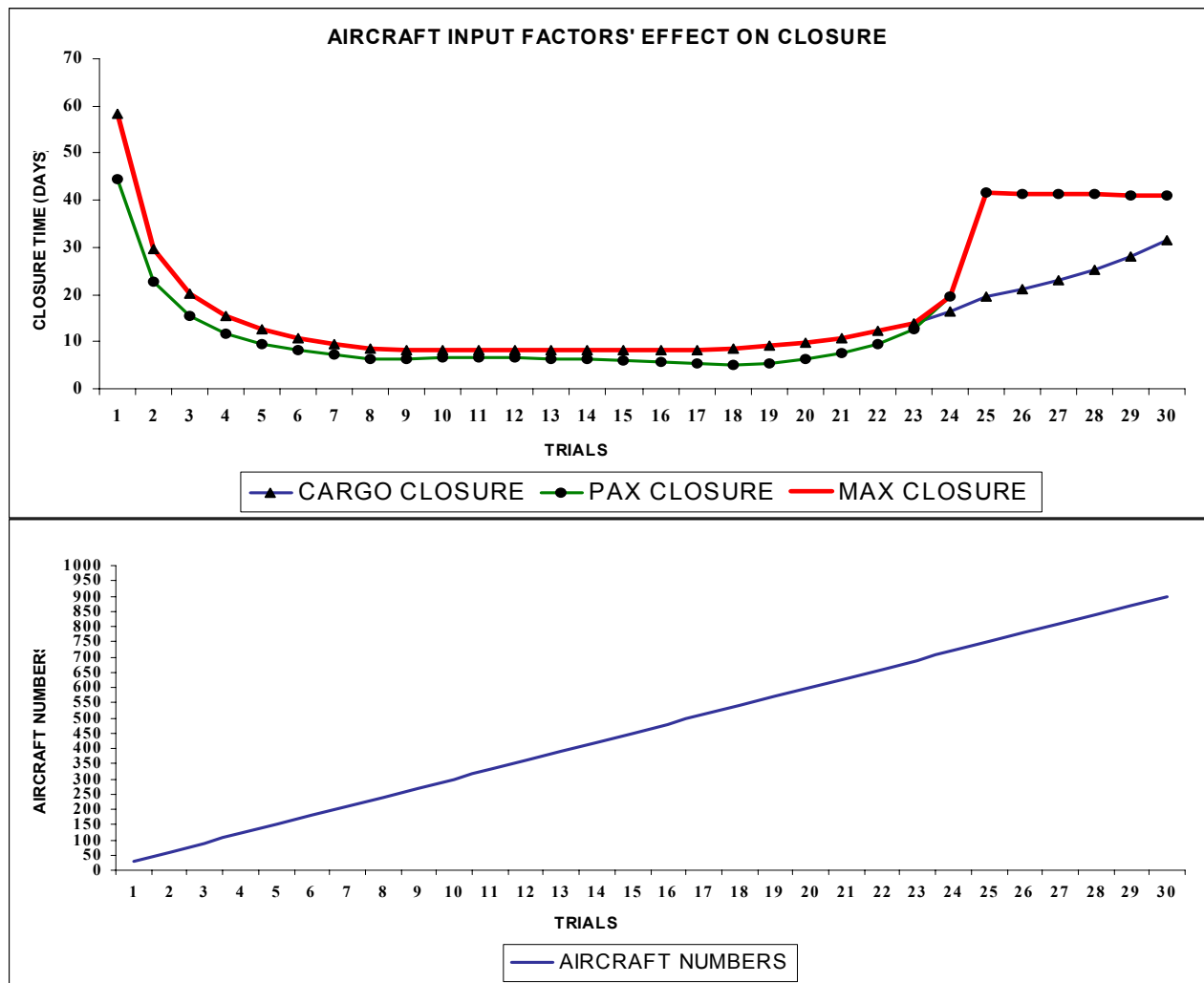


Figure 4-3. Chart of Aircraft Input Factors' Effect on Closure (3)

(Each aircraft allocation number is equal in increasing order)

Other than these, the reader should note that our analyses were performed under given specific scenario conditions which were referred to as fixed AMPCALC parameters at the beginning of this chapter. These scenario conditions may vary in real time conditions and when different scenario conditions applied to the above analysis,

different results may be obtained. For example, as the leg distances in the scenario increase, payload capability of aircrafts decreases and the block speeds of the aircraft increase. If we need to carry more outsize cargo in the mobility system modeled, then C-5s and C-17s gains importance in the model (see Table 4-2). We might also have constrained MOG in the scenario, which would make the aircraft working MOG values impact the closure time.

Conclusion

This chapter focused on the sensitivity analyses of the mobility system modeled by the AMC mobility planner's calculator (AMPCALC). First, 2^6 full factorial design with 6 center point runs were performed given two different scenario conditions and the effects of aircraft numbers on closure time and the nonlinear relation between those two were observed. Then, experimental design was performed for some AMPCALC input factors. Next, three cargo aircrafts, C-5, C-141, and C-17 were compared in 216 trials for different number of aircraft combinations. The results were examined and the mobility system modeled was discussed.

Chapter 5 presents future improvements and some potential research areas of the mobility system.

V. Further Improvements

Introduction

Chapter 5 presents suggestions for possible future areas of study. It also includes some suggestions about model improvements.

Future Research

In the model, aircraft allocation between the 4 independent cycles depends on user's decision. An optimization process may be set for allocating the aircrafts between 4 cycles. In this process, the user may be allowed to input some different weights for each cycle, so preemptive goal programming may be applied.

The aeromedical evacuation modeling can be improved. Destinations, according to the patient need, could be included in the model.

Distance calculation data base may be enhanced by adding Maximum On Ground (MOG) and base fuel limits (storage capacity, dispense rate). Then these data may allow input to the air refueling process and help determining MOG values in the airlift process.

Air refueling process can be improved via putting more constraints into the IP calculation. These constraints may be "booms available, aircraft configurations, summer or winter loading and fuel capacities of the aircrafts. Additionally the distance between the tanker's beddown base and the aerial refueling control point (ARCP) may be considered by the process.

As discussed in the statement of work in Appendix A., more advanced crew allocation methodology may improve the model capability and enhance its calculation logic. Therefore, following questions may be answered:

- What are the minimum numbers of crews of all aircraft types needed at each stage base to support a planned airlift flow?
- If the crews available fall short of these numbers, how should we efficiently allocate the number available to minimize cargo and pax closure time?

Adding a user form that includes “what if “ statements would help user to observe the effects of different constraint input values on results like closure time and cargo/pax throughput.

Some probabilistic calculations can be performed. Availability of the cargo and passengers, availability of aircrews in the specific points at specific times, mission delays because of the weather conditions, air traffic and airfield limitations may be modeling using probability values.

APPENDIX A. Statement of Work for AMPCALC.

Project Scope

The purpose of this project is to develop a computerized spreadsheet version of Air Force Pamphlet AFPAM 10-1403, Air Mobility Planning Factors. This pamphlet is designed to help service, joint, and combined planners to make gross estimates about mobility requirements in the early stages of the planning process. It covers strategic airlift, air refueling, and aeromedical evacuation (AE), both for peacetime and wartime operations. These planning factors often serve as a starting point for analyses involving more detailed, in-depth models and simulations of the air mobility system.

The pamphlet contains mobility planning factors such as aircraft block speeds, average payloads, fuel burn rates, ground times, etc. In addition, however, there are numerous formulas that allow planners to estimate the outcome of an operation in output measures such as closure time, number of aircraft required, aircraft use rates, pounds of fuel offloaded, etc. A major goal of this project is to develop spreadsheet formulas that will allow users to easily carry out the various calculations, and expand the formulas to include more complex air networks and mixed airlift fleets.

General Model Requirements

The following paragraphs outline some of the general model specifications of AMPCALC.

Microsoft Excel and Visual Basic for Applications (VBA)

Because Microsoft Excel and its internal macro language VBA are office systems standards throughout the Air Force, AMPCALC will be written in these languages to maximize its applicability across the air mobility community. The developer may also wish to create graphical representations of the model's output statistics and take advantage of Excel's excellent graphing capabilities.

Mathematical Algorithms

AMC/XPY currently uses an older Excel spreadsheet model, the Airlift Cycle Analysis Spreadsheet (ACAS), which concentrates on airlift operations. ACAS formulas are quite complex computationally, expanding on the planning factor formulas to incorporate mixed airlift fleets. Several heuristic methods and small linear programs (LPs) are used to solve these fleet mix problems. AMPCALC will require similar resource allocation techniques to expand and enhance the decision logic of the model.

AFPAM 10-1403 Coverage

Whereas ACAS concentrated on airlift planning, AMPCALC must also contain the formulas and factors related to aerial refueling and AE. As with ACAS, it may be possible to extend several of these formulas to incorporate mixed fleets or other complexities, which may require optimization or heuristic decision logic for aerial refueling and AE formulas as well.

Learning Tool for New Analysts

In addition to providing a tool for experienced analysts, AMPCALC shall be implemented in a form which assists new analysts in understanding the formulas and algorithms involved in obtaining simple air mobility plans. Wherever possible, AMPCALC should be written in a manner that allows the novice to build a “hands on” plan, making his own aircraft allocation and routing decisions. The new user can then observe the degree to which his plan meets various constraints and objectives, and compare his results with solutions generated by the algorithms and heuristics built into AMPCALC.

Model Functionality

The following paragraphs describe the essential features and capabilities required in AMPCALC. In defining this functionality, it is AMC/XPY’s intent to retain the current capabilities of ACAS, as well as introduce features that will increase model usability and make the model more capable of analyzing the full spectrum of AMC operations addressed by AFPAM 10-1403.

Improve Problem Set-up and Routing Calculations

ACAS presently requires that the analyst go to an outside source to obtain the great circle distances between bases and waypoints in each airlift route entered in the model. Both AFIT and XPY have access to an Excel spreadsheet called DISTCALC, which uses the great circle formula to quickly compute the distance between two points. The new AMPCALC model should incorporate a built-in great circle algorithm, which

uses a lookup table of latitude/longitude pairs matched to a large list of four-letter ICAO airfield identifier codes, much like that used in DISTCALC.

In addition, XPY desires a clearer and more concise procedure to determine aircraft block speeds and aircraft payload/range calculations. Block speed factors should be derived from the tables in AFPAM 10-1403. The payload/range calculations in ACAS use simplistic payload/range curves of unknown origin. These should be replaced by newer payload/range curves provided by XPY. Many aircraft loads fill the floor space or volume of the aircraft before reaching a maximum weight limit. To account for this, AMPCALC should use two payload inputs: the value calculated by the payload/range curves for a route, and a user-supplied average payload value. The lesser of these two values will be used to perform payload calculations.

Routes in AMPCALC, like those in ACAS, should specify the reason for the stop, whether or not the base is a crew stage, and head- or tailwinds. The 'reason for stop' is used to determine the type of ground time (en route, offload, onload, etc.) at each base, and hence affects calculations related to MOG, stage crews, and cycle times. A 'reason for stop' that is blank (representing a waypoint) or is an ERO (engine running or expedited offload) must be treated differently for fuel planning purposes. No fuel is given to the aircraft during these events, so calculations of aircraft fuel loads must treat the legs entering and leaving a waypoint or ERO base as if they were a single unrefueled 'leg'. Flying times and fuel burns should be corrected for wind effects before applying them to the airlift planning formulas and algorithms.

Multiple Aircraft Cycles

The ACAS spreadsheet allows the user to enter two airlift cycle routes in the model. The current implementation, however, can only look at the two routes as independent airlift scenarios, with each cycle using the entire available fleet and base MOG. In order to represent a more complex airlift situation, yet keep computation manageable, AMPCALC should be designed to allow up to four (4) airlift cycles. These cycles represent routing alternatives being employed simultaneously during a single airlift operation, thus the airlift fleet and base MOGs must be shared among the cycles. This requires allocation heuristics and algorithms to assure that air mobility assets are being used efficiently.

The expansion of the original ACAS concept to incorporate simultaneous routing of aircraft on multiple routes has significant implications for the design of AMPCALC. These are discussed in more detail in the following sections.

Multiple Airlift Requirements (Onload/Offload Pairs)

The airlift cycles mentioned above may be used to represent (1) multiple paths connecting a single onload base to a single offload base; (2) independent cargo requirements to be moved between different onload/offload base pairs; or (3) combinations of (1) and (2) above. For example, cycles A and B may provide two paths between onload base X and offload base Y; cycles C and D provide two paths between onload base U and offload base V. In this case the model will need a requirements vector showing the amount of outsize, oversize, bulk, and passengers to be moved from X to Y, and a second vector showing amounts to be moved from U to V.

In order to include scenarios with multiple onload/offload pairs, the requirements table in AMPCALC must be expanded to allow users to supply up to four cargo requirements (corresponding to four distinct onload/offload pairs).

Multiple MOG-Constrained Bases

Building scenarios with multiple routes may result in several routes sharing a common airfield. Thus an airlift plan must allocate portions of the MOG at the common field to each of the routes that pass through it. In addition, there may be several bases in the airlift network with MOG limitations affecting aircraft and cargo movement.

ACAS contains a heuristic to allocate MOG among the various aircraft types at a single MOG-constrained airfield. Once this allocation has been made, the various aircraft types can be treated as independent fleets, and the equations of AFPAM 10-1403 can be applied to each aircraft type separately. This heuristic often gives poor results, allocating more MOG to certain aircraft types than they are able to use. It also allocates MOG and cargo/pax workload among aircraft types in a way that results in passenger closure times that are significantly different from cargo closure times. The newest version of ACAS adds a small LP model that allocates MOG and workload in a way that minimizes overall closure time.

AFIT shall develop methods allowing AMPCALC to do efficient MOG allocation across all routes, aircraft types, and MOG bases. The model should be able to handle MOG restrictions at up to four bases in the airlift network.

Stage Crew Planning on Multiple Cycles

Just as an airfield's MOG must often be shared among aircraft flying different routes, crew stage bases that serve several routes must have enough crews to support them all. In some cases the airlift flow will be constrained by crews, in which case some type of crew stage allocation procedure must be used to determine the most efficient manning levels at critical stage bases.

AFPAM 10-1403 ignores crew planning, as it covers only single cycle operations. The simple formulas for setting up stages on a single cycle are incorporated in ACAS. In order to correctly represent multiple cycle operations, however, AMPCALC will need a more advanced crew allocation methodology. This must be designed to allow the airlift planner to answer two questions:

- What are the minimum numbers of crews of all aircraft types needed at each stage base to support a planned airlift flow?
- If the crews available fall short of these numbers, how should we efficiently allocate the number available to minimize cargo and pax closure time?

Planning for Commercial vs. Military Aircraft

Aircraft types should be labeled as either commercial CRAF or as organic military for planning purposes. CRAF planes use their own commercial infrastructure and crew scheduling procedures when activated for a contingency. Because of this, the model requires no stage crew planning formulas for commercial aircraft. In addition, MOG equations should account for commercial aircraft traffic only at a route's onload and offload bases (CRAF planes are assumed to make their en route stops at commercial airports near the airfields used by the military).

Base Fuel Constraints

A critical factor in recent airlift analyses is the daily fuel pumping capacities at en route bases. Many of our overseas bases are equipped with old fuel systems, often having hydrant systems with slow pumping rates and limited abilities to refuel multiple aircraft simultaneously. Others have a small bulk storage capacity, reducing their ability to handle a surge of large aircraft, even for a short period of time. Due to the limitations of these fuel systems, accurate airlift planning requires that fuel be explicitly represented in the planning equations, just as ute rates, crews, ground times, MOGs, and available aircraft are included in the AFPAM 10-1403 formulas.

In order to integrate fuel planning directly into airlift planning, AMPCALC should incorporate a “Base Fuel Limits” area in the spreadsheet where fuel system data, including the base resupply rate, bulk storage capacity, and dispense rate, can be entered next to a base’s four-letter ICAO identifier. It may be convenient to place this data with the latitude and longitude data used in calculating distances between ICAO locations. This data, together with leg lengths and the fuel burn rates in AFPAM 10-1403, can be used to determine the portion of a base’s total daily pumping capacity that is depleted when an aircraft of specific type departs from the base on a leg of specific length. These in turn will be used to report on the adequacy of each base’s fuel system to support a given airlift plan.

Air Refueling

AFPAM 10-1403 contains several tables of factors useful for air refueling planning. The tables, however, use average and/or historical data, and provide only a

gross estimate of the size and duration of an air refueling operation. More precise data on aircraft configuration, airspeed, altitude during refueling, etc. can be incorporated into the planning process, which will result in more accurate estimates. For our purposes, however, the basic planning factors and formulas included in AFPAM 10-1403 should provide adequate estimates.

In order to plan an aerial refueling operation, the planner must know the distance between the tanker's beddown base and the aerial refueling control point (ARCP), the total distance flown by the receiver, tanker offload rates, and air speeds and fuel burn rates for both the tanker and the receiver. AMPCALC shall incorporate a spreadsheet implementation of the basic AFPAM 10-1403 formulas that employs these user inputs to build rough air refueling plans.

In addition, XPY desires that AMPCALC be designed to allow nodes in the airlift network to represent air refueling points. The airlift plan will produce the mix and frequency of airlifters passing through the refueling point, and application of the basic air refueling formulas will determine the number of pounds of fuel that must be offloaded at that point each day. User inputs of tanker beddown bases, offload rates, and turnaround times can then be used to determine the number of tankers needed to support the airlift flow.

Aeromedical Evacuation

AMPCALC must be designed to include a worksheet that implements the aeromedical evacuation planning formulas of AFPAM 10-1403. These formulas give a rough approximation of the number of missions and medical crews required per day to move a given number of evacuees per day.

Hands-On Alteration of Airlift Plans

AMPCALC is intended to serve both as an analysis tool for experienced airlift analysts, and as an introduction to the air mobility system for newly assigned personnel with no mobility experience. To the extent possible, AFIT shall develop a spreadsheet layout that clearly labels the formulas and tables of planning factors, allowing the user to trace the series of calculations visually and confirm that they replicate the calculations specified in AFPAM 10-1403.

In addition, inexperienced analysts must be given the capability to ‘play’ with the model. This helps to develop an understanding of the impacts and interactions of ute rates, ground times, winds, and other factors. In order to provide the user with an additional means of experimenting with the airlift portion of AMPCALC, the program must allow the user to create his own airlift plan, and observe the degree to which it meets system objectives and constraints.

One of the AMPCALC worksheets must be set up to allow model users to specify the entire airlift plan (number of missions per day, by aircraft type and route) and create reports on the number of airlift resources that would be needed to fly such a plan. Note that this is the opposite of the original planning problem – in the planning problem, the resources (ute rates, stage crews, MOGs, and aircraft) are fixed, and various heuristics and algorithms are used to develop an airlift plan that moves cargo efficiently, but does not exceed the resource limits. The user-developed airlift plan simply requires that AMPCALC (1) compute all of the resources used in the execution of this plan; and (2) report this resource use, along with output measures such as closure date, tons moved per day, etc.

Deliverables

Progress Reports and Consultations

Making AMPCALC a reality will require close coordination between AFIT researchers and the mobility analysts in AMC/XPY. AFIT and XPY personnel must communicate frequently to evaluate progress, test model functionality, and resolve modeling difficulties. Most of this communication will take place by phone, or more likely e-mail. AMPCALC's Excel spreadsheet and VBA code is small enough to be transmitted by e-mail, allowing test versions and suggested modifications to be passed back and forth easily. At a minimum, AFIT and XPY should communicate at least once a week to assure that AMPCALC is effectively implemented in a timely and efficient manner.

Spreadsheet Layout Story-Boards

In the early stages of model design, AFIT shall provide XPY with some rough “story-boards” depicting the intended layout of input cells, output cells, and intermediate calculations on Excel worksheets. XPY shall evaluate these to determine:

- how well they assist new users in grasping the concepts of air mobility planning, as specified in paragraph “Learning tool for new analysts”
- how efficiently experienced analysts can navigate among the various worksheets and tables to build or modify air mobility plans.

XPY will respond as quickly as possible with suggestions for changing the layout of data and formulas. The final layout will be resolved, again as quickly as possible, by consultation between AFIT and XPY.

Model Documentation

The value of AMPCALC as an instructional and analytic tool depends greatly on the ease with which XPY analysts and future AFIT students can refine and modify the code. VBA code within the AMPCALC program shall be documented sufficiently to allow other analysts and programmers to follow program logic. If the program employs complex algorithms or heuristics (iterative calculations, genetic algorithms, response surfaces, etc.), more detailed documentation of these methods and their implementation will be required to assure the program's maintainability.

APPENDIX B. Mobility Models

Airlift and Sealift Cycle Analysis Model (ASCAM)

ASCAM is a mobility model used by US Transportation Command. It is an Excel based model for quickly estimating how long it takes to move cargo from one point to another.

Airlift Cycle Analysis Spreadsheet (ACAS)

The Airlift Cycle Analysis Spreadsheet (ACAS) allows the user to evaluate the airlift system performance of two simultaneous cycles, using up to 11 different aircraft types. This spreadsheet combines the cycle analysis methodologies of AFPAM 10-1403 (Airlift Planning Factors), the MAC airlift Planning Guide, the Airlift Operations School Airlift Capabilities and Contingency Planning Seminars, the USAF Master Plan, and Desert Shield/Storm experience.

Base Resource and Capability Estimator (BRACE)

BRACE is an animated simulation model. It is designed to provide an in-depth analysis of operations and resource utilization at an individual airfield. The main outputs include an estimate of the maximum throughput rate and working maximum-on-ground (MOG). These parameters can then be used as inputs for large-scale mobility models such as MASS.

Global Deployment Analysis System (GDAS)

A high-resolution comprehensive simulation of deployment from origin to tactical assembly area (TAA). A multi-modal network; addressing air, sea, rail and road. It schedules to achieve timely, balanced and resource efficient deployment. Detailed patterns of constraints for networks, vehicles and facilities are included. Models surprise events, diversions, clustered movement and target ratios. The model can be used to provide either capability or requirements determination.

Regional Force Projection Tool (RFPT)

The purpose of the Regional Force Projection Tool (RFPT) is to provide the Air Force with quick-turn analysis of mobility issues for regional scenarios.

Mobility Analysis Support System (MASS)

MASS is the Air Mobility Command's legacy model for strategic airlift. It was designed by former members of AMC studies and analysis section to accurately model the strategic airlift environment for analysis of doctrine, strategic airlift capability, current AMC airlift assets and future AMC acquisitions. This model is used primarily by AMC/XPY, the studies and analysis section at Scott AFB.

Generalized Air Mobility Model (GAMM)

GAMM is a detailed simulation model that serves as the primary analytical tool for future theater airlift studies.

Strategic Transport Optimal Routing Model (STORM)

STORM is a linear programming model used to select the mix of routes and aircraft that will meet the monthly cargo and frequency requirements while minimizing the costs of cargo handling, military aircraft operations, and commercial aircraft leasing. Its primary owner and user is AMC Studies and Analysis Flight.

In his thesis research Chanseok (1997) explains STORM as follows. The Strategic Transport Optimal Routing Model (STORM) is based on a model built by Barton and Guiriaer (1967) of Lockheed to analyze the peacetime employment of the new C-5 cargo plane. Storm was developed at Air Mobility Command (then the Military Aircraft Command) to assist in a major study of the entire scheduled cargo system that must provide two main types of service to its overseas customers. The first is to provide sufficient cargo capacity for a given period of time (usually for one month) to meet all demands for cargo movement between the pairs of bases in the system. This cargo capacity is known as the cargo requirement. The second is to provide a minimum number of flights per month between certain cities. This number is called the frequency requirement. The basic purpose of STORM is to select the mix of routes and aircraft that will meet the monthly cargo and frequency requirements of AMC while minimizing the cost of cargo handling, military aircraft operations, and commercial aircraft leasing (Ackley *et al.*, 1992).

MIDAS

MIDAS is the strategic mobility model used by the Joint Staff and OSD.

Analysis Mobility Platform (AMP)

AMP accesses several mobility models in order to accomplish end to end mobility modeling. Its primary user is USTRANSCOM.

NPS/RAND Mobility Optimizer (NRMO)

NRMO is a linear programming model developed by Naval Postgraduate School and RAND to model strategic air mobility. The model was developed for Air Force Studies and Analyses Agency.

Joint Flow and Analysis System for Transportation (JFAST)

A PC-based analysis tool for estimating deliberate planning, exercise and “real-world” transportation (Airlift and Sealift); with the capability to generate notional TPFDDs. It allows logistics planners to analyze the transportation requirements of a military operations plan or course of action. Simulates the strategic movement of troops, equipment, and supplies from Origin to Point of Debarkation (POD); and using graphics and mapping technology, presents the results in a form ready for decision makers. The airlift closure model simulates airlift flows by making day-by-day assignment of individual requirements to lift capabilities.

Joint Educational Mobility Model (JEMM)

A model developed to introduce students (primarily PME) and exercise participant to mobility and its modeling. It is owned by the Air Force Wargaming Center at Maxwell AFB.

Enhanced Logistics Intratheater Support Tool (ELIST)

The model simulates ‘fort to port’ and JRSO&I deployment processes by “flowing” a TPFDD over a theater’s transportation infrastructure.

Air Mobility Operations Simulator (AMOS)

AMOS is a new model currently under development at AMC. The development effort has several goals. Some of the goals are:

- Develop and field a simulation model that provides critical insights into air mobility issues;
- Increase usability while keeping maintenance and enhancement cost to a minimum;
- Build a model architecture that will meet AMC’s needs for the next 15 years.

APPENDIX C. Users' Guide for AMPCALC

What is AMPCALC, What Does It Include?

Air Mobility Command Mobility Planner's Calculator (AMPCALC) is both a training tool and a model for novice or experienced air mobility planners, which allows users to easily carry out various calculations about mobility requirement estimates of strategic airlift, air refueling and aeromedical evacuation (AE) operations, including aircraft ramp use optimization and air refueling performance optimization of any leg distance, for peacetime or wartime.

The major aspects of AMPCALC are:

- airlift screens; including input screens, calculation screens, output screens and ramp use optimization screen,
- air refueling screen,
- aeromedical evacuation screen,
- distance calculation screen and
- Information screens; including entrance screen, instructions, glossary and formulas screens.

AMPCALC's airlift screens and aeromedical evacuation screen are designed to perform calculations for four simultaneous airlift cycles using up to fifteen different types of aircrafts. The airlift input screens and the aeromedical evacuation input screen allow users to input scenario requirements. Calculation and output screens show calculation or final output values.

AMPCALC's air refueling screen performs calculations using up to fourteen different types of air refuelable aircraft with three tanker aircraft types. It also has a tanker optimization feature which shows the minimum number of tankers to meet the air refueling mission requirements for particular legs of a cycle.

The aeromedical evacuation screen helps to determine aeromedical mission and crew capability for particular patient levels. It has one input column, which shows the number of patients that need to be evacuated.

The distance calculation screen, in which there are over 2000 locations addressed by the DISTCALC spreadsheet, is embedded into AMPCALC so the user is able to find the distance between locations. The distance calculation sheet is linked with the air refueling and routing input screens which need leg distances in their calculations.

In the model, all cells are protected, except the input cells. Unprotected cells, that is, the input cells, are blue on white. Calculation and output cells are green on yellow and the optimization cells are light orange on white. Black and red are used for headings.

As we described above, the user can easily identify the input columns and change them, since they are blue on white. However, he/she does not have the ability to change the columns in other colors, such as, green lettered columns which are allocated for calculation and output values and the light orange colored optimization cells. As we explain in the next paragraph, there is one exception. The aircraft type column in the aircraft standard planning factors input screen is unprotected to allow users to select and add aircraft types.

In AMPCALC, the airlift screens and aeromedical evacuation screen display aircraft types in the leftmost column. AMPCALC's default aircraft set includes KC-135,

C-5, C-141, C-17, KC-10, DC-10 Cargo, B-747 Cargo, MD-11F, any Wide Body Pax(WBPax), any Wide Body Cargo(WBC), any Narrow Body Cargo(NBC) and 4 NEW aircraft types. The user can enter any aircraft type in place of the Aircraft Types column in place of NEW-1, NEW-2, NEW-3 and NEW-4 labels. The user can also identify another aircraft type, such as, a C-130 instead of a C-17 Pax, since the user is always able to modify aircraft types. When the user decides to change or add any aircraft in the model, it is sufficient to just change the aircraft standard planning factors input screen rather than all screens. Since other screens are linked to this screen, making a change in this screen's aircraft type column automatically changes aircraft headings on all other screens. However, making this change does not change the maximum payloads and cycle blockspeed formulations. These values are the functions of leg distances for each aircraft type. They are regressed values from the payload and distance tables in Air Force Pamphlet 10-1403. When the user changes the name of one of the aircraft, he/she also needs to enter the new aircraft's maximum payload (in capability statistics screen) and blockspeed (in blockspeeds screen) formulations. For "New 1, New 2, New 3, New 4" Aircraft, the default is the regressed maximum payload and blockspeed formulations for the NBC aircraft's formulations.

The air refueling screen, aeromedical evacuation screen and distance calculation screen inputs and outputs are independent of the airlift screens.

The ramp use optimization screen includes optimized cargo/pax missions per day, cargo/pax throughputs per day and closure times outputs.

Information screens, especially instructions, glossary and formulas screens are for information. The user searches in the available data list via using comboboxes embedded

in related sheets. In addition to this, the model includes information user forms, one or more for each screen. When the user needs information, they click the “Screen Information” button found on each sheet. These buttons activate a screen related information page.

How does AMPCALC work?

In AMPCALC, airlift screens have eight input screens for four independent cycles in which each cycle uses the aircraft and aircrew sources independently. These input screen values determine limitations on aircraft, aircrews, and cargo/pax such as MOG constraints, 30/90 day aircrew limits, maximum payload values, pax with cargo capabilities, allocated aircraft numbers and identifies the route that is followed in the airlift cycle. In aircraft standard planning factor screen, % cargo with pax column determines the cargo missions that can also carry pax. Aircraft allocation numbers are entered for the aircraft allocation screen. Maximum on the ground (MOG) constraints by aircraft types (wide/narrow body) and controlling MOG location in the stop points are entered into the aircraft MOG summary “or” values screen and aircraft ground times input screen, respectively. Cargo and pax requirements are entered by their category into the allowable aircraft cargo and cargo requirements input screen. Cycle stop points are entered routing input screen with their stop and stage factors and wind correction values. Then AMPCALC ’s major outputs, cargo/pax throughput and closure values, are calculated.

In the ramp use optimization screen, the user may try different MOG constraints, cargo type permissions, and aircraft availability values. So, he/she can check the outputs of some “what if” conditions for the airlift scenario.

In the AMPCALC, the user inputs the total available aircraft numbers. Then the user determines the number of aircraft allocated to each of four cycles. There is no requirement to match the available and allocated aircraft numbers. AMPCALC uses the aircraft that are allocated to a cycle.

When the user chooses leg points in the routing input comboboxes and clicks on the “push to renew distances” command button, the name of the points in the default base list are found. Their latitude and longitude are determined and great circle formula distance calculations are performed. After performing these calculations, the distance column values of the routing inputs screen are determined and distributed to other linked screens automatically, such as block speeds screen.

After entering all data into the model airlift screens, major outputs are taken in throughput and closure screen. These are, the average number of passengers and cargo carried per day (cargo/pax throughput) and their closure times in days.

The ramp use optimization screen uses the same data for average payload, 1-way time, non-ramp interval and MOG base ground time with the model; however, as we said before, aircraft cargo/pax permission, aircraft capability and work MOG constraints can be controlled by the user to be able to observe their effects on the optimization process. In this screen, optimization of the aircraft ramp uses is carried on. First, user enters input values and then clicks on the "optimize ramp use" button to initiate the process. In this optimization process, minimum of the cargo-pax throughput bounds, which are the ratios

of allocated cargo/passenger types over cargo passenger requirements, are being maximized subject to some constraints. These constraints are total missions should be less than or equal to maximum missions per day, total ramp share percentages of each aircraft should be less than or equal to one hundred percent, and allocated cargo/passenger throughputs should be less than or equal to those of maximum ability of aircrafts calculated by cargo/passenger permission input values. Maximization of the minimum of cargo-pax throughput bounds decreases closure time and increases cargo and pax daily throughput values.

In the aeromedical evacuation screen, the number of evacuees is the only input value. Aircraft load planning factors which show standard number of patients loaded per aircraft for aeromedical evacuation, crew per aircraft, crew planning factor and crew cycle time values are already entered in related columns of this screen. Aeromedical evacuation missions and aeromedical evacuation crews needed are the output values of this screen.

In the air refueling screen, the user should calculate the leg distance that will be flown via going to the distance calculation screen (click the "distance calc." command button). Since calculated distance value is linked to air refueling screen, when the user calculates the distance in distance calculation screen, the calculated distance automatically appears in the air refueling screen. Then the user chooses the tanker aircraft types that will be used in the air refueling process by checking the related check boxes. The second column is for choosing receiver aircrafts and their numbers. In this column, last three cells show the optimized tanker numbers. Additionally, the user, according to the required fuel reserve values at the destination point, should make inputs

in the destination reserve column. Fuel burn rates and total fuel values are already included in the model since they are fixed values taken from Air Force Pamphlet 10-1403. After all input values are entered, click the optimization command button which displays the tanker optimization user form, so the user can instruct AMPCALC to perform the tanker optimization process. The optimization process gives the optimized number of tankers for the air refueling operation.

In the distance calculation screen, there are two ways to calculate leg distances. One is via choosing leaving and arriving points in the comboboxes provided. Comboboxes may have a list of base names or list of ICAO names according to user preference.

The user can control this feature by clicking on "push for name list/push for ICAO list" command button located below the screen. Another way of calculating distance is entering latitude and longitude values of leaving and arriving points in degree and minute values into the related textboxes and checking the direction of those in the check boxes under them.

After using any of the text boxes or check boxes, if the user wants to use name/ICAO list for other calculation, first he/she should change previous names of both comboboxes and then enter the new names again. Otherwise, incorrect calculations may occur.

Input Factors In AMPCALC

AMPCALC's input factors are represented with some coded numbers or percentage values except 30/90 day limit factor which shows the maximum allowed 30/90 day crew working hour limits. Other factors are;

MC rate factor, use rate factor, payload factor, ground time factor, capability limit factor, block speed factor, in/out factor (MOG Visited), stop factor, stage factor, crew limit factor, call up factor, augment factor, and waiver factor.

MC rate factor determines the mission capable rate of the aircrafts in AMPCALC. MC rate factor of 0 or 1 shows average fully mission capable rates for each aircraft type as a percentage of total PAA. 0 value of MC rate gives %100 percent MC rate of the aircraft.

Use rate factor shows the limit on aircraft use in hours per day for each aircraft type. The value of 0 represents war or surge utilization rate while the value of 1 represents alternate use rate conditions.

Payload factor determines the desired limit on aircraft average payloads in tons for each aircraft type. Payload factor of 0 shows war payload values while the payload factor value of 1 shows the desert storm or alternate payload values.

Ground time factor determines which column of ground time values is to be used in the model. These are desert storm or air mobility master plan ground time values. Ground time factor of one refers desert storm ground time values and the factor of 0 refers to air mobility master plan ground times.

The capability limit factors show the type of location in the network against which the working MOG constraint applies. For example if the offload is marked with a one (1), it means the controlling MOG is at the offload location.

Block speed factor determines the planned block speed for the mobility system in AMPCALC. Block speed value of 0 represents the standard block speed values, value of 1 represents the alternate block speed values and the factor value 2 represents the block speeds derived from the tables in AFPAM 10-1403, which are the functions of related leg distance values.

In/out (MOG Visited) factor allows input of cycle MOG (Maximum Aircraft on the Ground) values. If the cycle returns using the same route and if the overall cycle MOG constraint exists because of limitations in the enroute structure (not at the onload or offload), then a one (1) is entered for this factor. If, however, either a different return routing is used or if the cycle working MOG constraint exists at the onload or the offload, then a zero (0) response is entered for this factor.

Followings are the stop factors of AMPCALC. Blank=waypoint w/o stop, 0=None, 1=Onload, 2=Enroute, 3=Offload, 4=Engine Running Offload (ERO), 5=Onload/Offload Combination

Stage factor of 1 shows that stop point is the crew stage location in the network, 0 value shows that it is not.

Crew limit factor in AMPCALC shows whether there is limitation on active crews and reserve crews. If the factor value is 0, there is no limitation, otherwise crew limits are constraint for the model.

Call Up Factor shows call up percentage will be applied for military (non-CRAF) aircrafts.

Augment factor value determines normal and waived total mission amounts that are expected to use augmented crews in AMPCALC.

Waiver factor allows whether the input of a less restrictive crew limits (waived limits) would be used in the model. Waiver factor of 1 shows that waived limits are used, if it is 0, normal limits are used in the system.

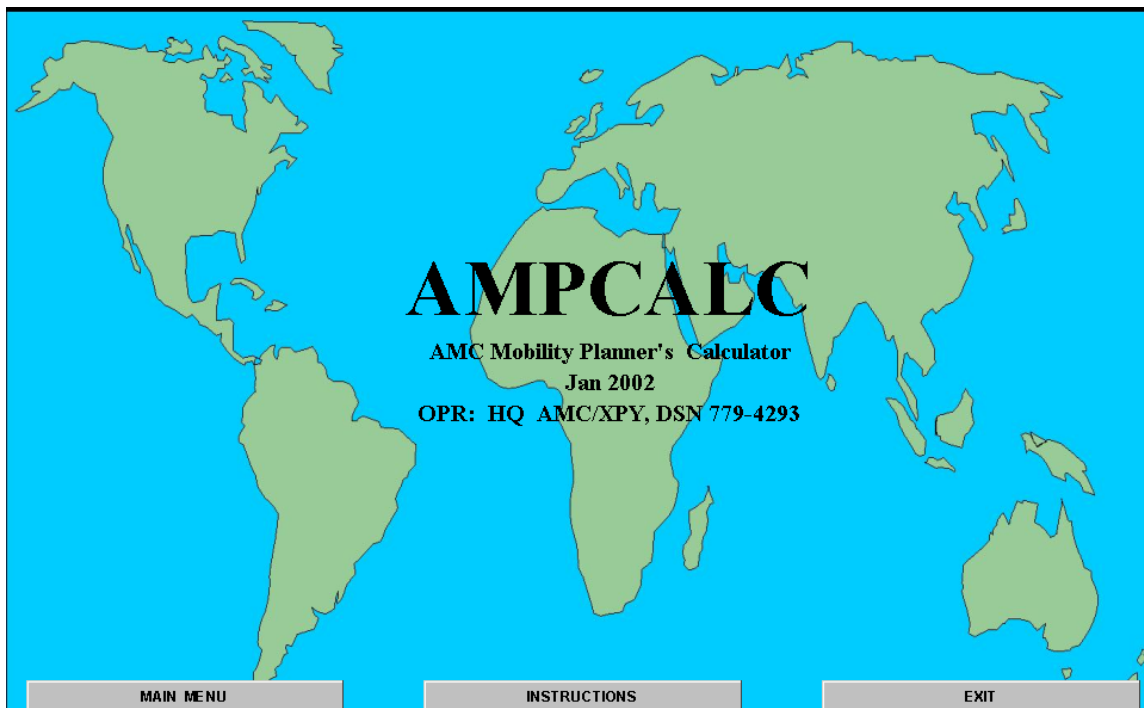
Parametric Analysis of 3 Main Cargo Aircrafts in AMPCALC

<u>Trials</u>	<u>Number of C-5</u>	<u>Number of C-141</u>	<u>Number of C-17</u>	<u>Cargo Closure</u>	<u>Passenger Closure</u>	<u>Max Closure Cargo/Pax</u>	<u>Cargo Throughput</u>	<u>Passenger Throughput</u>
91	20	30	0	15.49	8.42	15.49	1,680.58	3,851
92	20	30	10	13.82	8.45	13.82	1,887.63	3,903
93	20	30	20	12.50	8.47	12.50	2,088.90	3,952
94	20	30	30	11.42	8.48	11.42	2,287.31	4,001
95	20	30	40	10.53	8.50	10.53	2,482.91	4,049
96	20	30	50	9.77	8.51	9.77	2,675.75	4,096
97	20	40	0	15.17	8.37	15.17	1,716.32	3,871
98	20	40	10	13.57	8.40	13.57	1,922.89	3,922
99	20	40	20	12.30	8.43	12.30	2,123.66	3,972
100	20	40	30	11.25	8.45	11.25	2,321.56	4,020
101	20	40	40	10.39	8.47	10.39	2,516.67	4,068
102	20	40	50	9.65	8.48	9.65	2,709.02	4,115
103	20	50	0	15.17	8.37	15.17	1,716.32	3,871
104	20	50	10	13.57	8.40	13.57	1,922.89	3,922
105	20	50	20	12.30	8.43	12.30	2,123.66	3,972
106	20	50	30	11.25	8.45	11.25	2,321.56	4,020
107	20	50	40	10.39	8.47	10.39	2,516.67	4,068
108	20	50	50	9.65	8.48	9.65	2,709.02	4,115
109	30	0	0	15.53	8.21	15.53	1,672.93	3,889
110	30	0	10	13.85	8.26	13.85	1,879.68	3,941
111	30	0	20	12.52	8.30	12.52	2,080.68	3,991
112	30	0	30	11.44	8.33	11.44	2,278.83	4,040
113	30	0	40	10.54	8.36	10.54	2,474.17	4,088
114	30	0	50	9.79	8.38	9.79	2,666.75	4,135
115	30	10	0	14.94	8.14	14.94	1,740.42	3,926
116	30	10	10	13.39	8.19	13.39	1,946.44	3,978
117	30	10	20	12.15	8.24	12.15	2,146.62	4,027
118	30	10	30	11.13	8.27	11.13	2,343.97	4,076
119	30	10	40	10.29	8.30	10.29	2,538.52	4,124
120	30	10	50	9.57	8.33	9.57	2,730.34	4,171
121	30	20	0	14.40	8.07	14.40	1,806.40	3,961
122	30	20	10	12.96	8.13	12.96	2,011.56	4,013
123	30	20	20	11.80	8.18	11.80	2,210.79	4,063
124	30	20	30	10.84	8.22	10.84	2,407.21	4,112
125	30	20	40	10.04	8.25	10.04	2,600.85	4,160
126	30	20	50	9.36	8.28	9.36	2,791.79	4,207
127	30	30	0	13.90	8.00	13.90	1,872.07	3,997
128	30	30	10	12.56	8.07	12.56	2,076.37	4,049
129	30	30	20	11.47	8.12	11.47	2,274.66	4,099
130	30	30	30	10.57	8.17	10.57	2,470.16	4,147
131	30	30	40	9.81	8.20	9.81	2,662.91	4,195
132	30	30	50	9.16	8.24	9.16	2,852.96	4,242
133	30	40	0	13.64	7.97	13.64	1,907.26	4,017
134	30	40	10	12.35	8.04	12.35	2,111.10	4,068
135	30	40	20	11.30	8.09	11.30	2,308.90	4,118

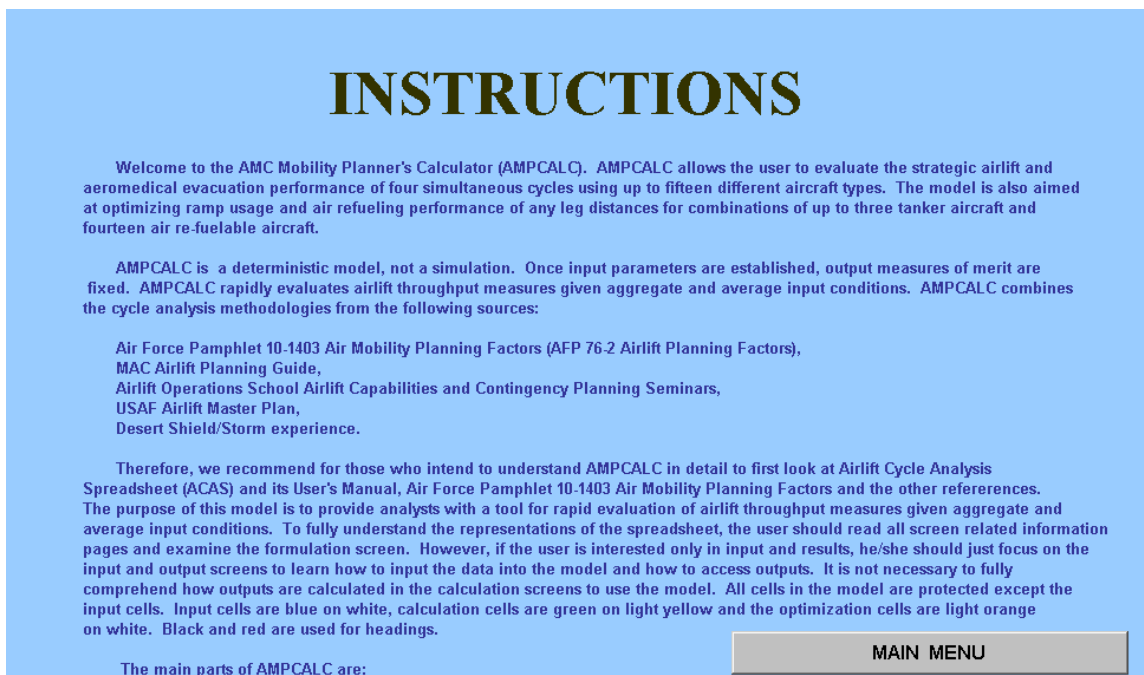
Trial#	Number of C-5	Number of C-141	Number of C-17	Cargo Closure	Passenger Closure	Max Closure Cargo/Pax	Cargo Throughput	Passenger Throughput
136	30	40	30	10.43	8.14	10.43	2,503.91	4,166
137	30	40	40	9.69	8.18	9.69	2,696.17	4,214
138	30	40	50	9.06	8.21	9.06	2,885.76	4,260
139	30	50	0	13.64	7.97	13.64	1,907.26	4,017
140	30	50	10	12.35	8.04	12.35	2,111.10	4,068
141	30	50	20	11.30	8.09	11.30	2,308.90	4,118
142	30	50	30	10.43	8.14	10.43	2,503.91	4,166
143	30	50	40	9.69	8.18	9.69	2,696.17	4,214
144	30	50	50	9.06	8.21	9.06	2,884.14	4,260
145	40	0	0	13.93	7.81	13.93	1,864.15	4,035
146	40	0	10	12.59	7.90	12.59	2,068.18	4,087
147	40	0	20	11.50	7.97	11.50	2,266.21	4,137
148	40	0	30	10.59	8.03	10.59	2,461.45	4,186
149	40	0	40	9.83	8.08	9.83	2,653.95	4,233
150	40	0	50	9.19	8.12	9.19	2,843.76	4,280
151	40	10	0	13.46	7.76	13.46	1,930.77	4,071
152	40	10	10	12.21	7.85	12.21	2,134.08	4,124
153	40	10	20	11.19	7.92	11.19	2,331.31	4,173
154	40	10	30	10.33	7.98	10.33	2,525.77	4,222
155	40	10	40	9.61	8.03	9.61	2,717.50	4,269
156	40	10	50	9.00	8.08	9.00	2,906.56	4,316
157	40	20	0	13.03	7.71	13.03	1,995.75	4,107
158	40	20	10	11.86	7.80	11.86	2,198.22	4,159
159	40	20	20	10.89	7.88	10.89	2,394.52	4,209
160	40	20	30	10.09	7.94	10.09	2,588.08	4,257
161	40	20	40	9.40	7.99	9.40	2,778.92	4,304
162	40	20	50	8.81	8.04	8.81	2,967.11	4,351
163	40	30	0	12.62	7.67	12.62	2,060.43	4,143
164	40	30	10	11.53	7.76	11.53	2,262.06	4,195
165	40	30	20	10.62	7.83	10.62	2,457.45	4,244
166	40	30	30	9.85	7.90	9.85	2,650.11	4,292
167	40	30	40	9.20	7.95	9.20	2,840.07	4,339
168	40	30	50	8.64	8.00	8.64	3,027.41	4,385
169	40	40	0	12.41	7.64	12.41	2,095.10	4,162
170	40	40	10	11.36	7.73	11.36	2,296.28	4,214
171	40	40	20	10.48	7.81	10.48	2,491.18	4,263
172	40	40	30	9.73	7.88	9.73	2,683.35	4,311
173	40	40	40	9.10	7.93	9.10	2,872.85	4,358
174	40	40	50	8.60	7.97	8.60	3,042.86	4,404
175	40	50	0	12.41	7.64	12.41	2,095.10	4,162
176	40	50	10	11.36	7.73	11.36	2,296.28	4,214
177	40	50	20	10.48	7.81	10.48	2,491.18	4,263
178	40	50	30	9.73	7.88	9.73	2,683.35	4,311
179	40	50	40	9.10	7.93	9.10	2,872.85	4,358
180	40	50	50	8.63	7.96	8.63	3,030.52	4,404

Trial	Number of C-5	Number of C-141	Number of C-17	Cargo Closure	Passenger Closure	Max Closure Cargo/Pax	Cargo Throughput	Passenger Throughput
181	50	0	0	12.66	7.50	12.66	2,052.27	4,180
182	50	0	10	11.56	7.60	11.56	2,253.63	4,232
183	50	0	20	10.65	7.69	10.65	2,448.76	4,282
184	50	0	30	9.88	7.77	9.88	2,641.16	4,330
185	50	0	40	9.23	7.83	9.23	2,830.89	4,377
186	50	0	50	8.66	7.89	8.66	3,017.99	4,423
187	50	10	0	12.28	7.46	12.28	2,118.04	4,217
188	50	10	10	11.25	7.57	11.25	2,318.70	4,269
189	50	10	20	10.39	7.66	10.39	2,513.04	4,318
190	50	10	30	9.66	7.73	9.66	2,704.69	4,366
191	50	10	40	9.04	7.80	9.04	2,893.66	4,413
192	50	10	50	8.50	7.86	8.50	3,080.03	4,459
193	50	20	0	11.92	7.42	11.92	2,182.05	4,252
194	50	20	10	10.95	7.53	10.95	2,381.88	4,304
195	50	20	20	10.14	7.62	10.14	2,575.32	4,353
196	50	20	30	9.45	7.70	9.45	2,766.08	4,401
197	50	20	40	8.85	7.77	8.85	2,954.19	4,448
198	50	20	50	8.34	7.82	8.34	3,139.71	4,493
199	50	30	0	11.59	7.39	11.59	2,245.76	4,288
200	50	30	10	10.67	7.50	10.67	2,444.78	4,340
201	50	30	20	9.90	7.59	9.90	2,637.33	4,389
202	50	30	30	9.25	7.67	9.25	2,827.21	4,436
203	50	30	40	8.68	7.73	8.68	3,014.46	4,482
204	50	30	50	8.25	7.77	8.25	3,175.96	4,527
205	50	40	0	11.42	7.37	11.42	2,279.91	4,307
206	50	40	10	10.53	7.48	10.53	2,478.50	4,359
207	50	40	20	9.78	7.57	9.78	2,670.56	4,407
208	50	40	30	9.14	7.65	9.14	2,859.97	4,455
209	50	40	40	8.63	7.71	8.63	3,033.84	4,501
210	50	40	50	8.21	7.79	8.21	3,188.87	4,522
211	50	50	0	11.42	7.37	11.42	2,279.91	4,307
212	50	50	10	10.53	7.48	10.53	2,478.50	4,359
213	50	50	20	9.78	7.57	9.78	2,670.56	4,407
214	50	50	30	9.14	7.65	9.14	2,859.97	4,455
215	50	50	40	8.66	7.69	8.66	3,021.38	4,501
216	50	50	50	8.24	7.74	8.24	3,177.98	4,538

APPENDIX D. AMPCALC Screens



Entrance Screen



Instructions Screen

MAIN MENU

INPUT SCREENS	AIRLIFT SCREENS CALCULATION SCREENS	OUTPUT SCREENS
AIRCRAFT STANDARD PLANNING FACTORS INPUT	AIRCRAFT CARGO ELIGIBILITY	MISSION STATISTICS
AIRCRAFT GROUND TIMES INPUT	AIRCRAFT MOG SUMMARY "AND" VALUES	MISSION TIMES
AIRCRAFT ALLOCATION	WORKING TABLE	CAPABILITY STATISTICS
ALLOWABLE CARGO AND REQUIREMENTS INPUT	BLOCK SPEEDS	FLOW/INTERVAL LIMITS
AIRCREW CALL-UP AND AIRCREW LIMITS INPUT	CORRECTED DISTANCES	AIRCRAFT USE /UTE RATES
ROUTING INPUT	FLYING TIMES	AIRCRAFT STATISTICS
AIRCRAFT MOG SUMMARY "OR" VALUES	GROUND TIMES	THROUGHPUT AND CLOSURE
RAMP USE OPTIMIZATION		CREW SUMMARY
AIR REFUELING SCREEN	AEROMEDICAL EVAC. SCREEN	DISTANCE CALCULATION SCR.
AIR REFUELING	AEROMEDICAL EVACUATION	DISTANCE CALCULATION
INFORMATION SCREENS		
ENTRANCE SCREEN	GLOSSARY	
INSTRUCTIONS	FORMULAS	EXIT

Main Menu Screen

GLOSSARY

The glossary was included to assist those new to AMPCALC while providing a valuable reference tool for all users.

The glossary below contains two parts; definitions and acronyms. Definitions and acronyms are arranged in alphabetical order and contains most of the terms encountered when using AMPCALC.

Use the windows below to search for definitions and acronyms.

[MAIN MENU](#)

**USE THE WINDOW BELOW
TO SEARCH FOR DEFINITIONS**

USE Rate

**USE THE WINDOW BELOW
TO SEARCH FOR ACRONYMS**

PACAF

Glossary Screen

FORMULAS

SEARCH FOR THE FORMULA IN BOX BELOW

UTE RATE

Below are some formulations that are used in AMPCALC in alphabetical order.

MAIN MENU

ACTUAL PRODUCTIVITY FACTOR = (ONE WAY ENROUTE FLYING TIME) / (RTF + ORI

Formulas Screen

AIRCRAFT STANDARD PLANNING FACTORS INPUT																		
Aircraft (Type)	Act/AR PAA	ARC/UE PAA	Withhold Tng/Other	MC Rate for Use	Avail 0=Off 1=On	MC Rate Factor 0=Off 1=On	# Pax w Cargo	# Pax w/o Crghw Pax	% Cargo w Cargo	Object Average Surge	Surge	Alternate UseRate	AMMP UseRate	Alternate Payload	Planned Payload	Block Spd.	Speed Factor 0=NewStd 1=Alternate	
KC-135	241	222	0	100%	463	100%	89%	0	46	100%	5.60	13.00	5.60	5.60	13.00	13.00	419	419
C-5	70	34	0	100%	104	100%	75%	51	51	100%	10.60	61.30	10.60	6.80	61.30	61.30	409	409
C-141	162	52	0	100%	214	100%	83%	11	120	100%	12.10	19.00	12.10	7.40	19.00	19.00	394	405
C-17	96	6	0	100%	102	100%	90%	11	90	100%	15.15	45.00	15.15	11.70	45.00	45.00	410	410
KC-10	57	0	19	100%	38	100%	93%	0	68	100%	12.50	32.60	12.50	7.90	32.60	32.60	434	434
DC-10	47	0	0	100%	47	100%	95%	0	180	100%	10.00	62.00	10.00	10.00	62.00	62.00	444	455
B-747F (Mix)	38	0	0	100%	38	100%	95%	7	335	100%	10.00	86.00	10.00	10.00	86.00	86.00	454	465
MD-11F	63	0	0	100%	63	100%	95%	0	315	100%	10.00	80.00	10.00	10.00	80.00	80.00	440	455
VBP Equiv	122	0	0	100%	122	100%	95%	0	335	100%	10.00	46.50	10.00	10.00	53.00	46.50	454	465
VBC Equiv	131	0	0	100%	131	100%	95%	0	0	100%	10.00	78.00	10.00	10.00	73.00	78.00	454	465
NBC	9	0	0	100%	9	100%	93%	0	0	100%	10.00	33.00	10.00	10.00	33.00	33.00	429	440
NEV-1	1	0	0	100%	1	100%	93%	0	0	100%	0.00	0.00	0	0	0	0	419	419
NEV-2	0	1	0	100%	1	100%	93%	0	0	100%	0.00	0.00	0	0	0	0	409	409
NEV-3	1	0	0	100%	1	100%	93%	0	0	100%	0.00	0.00	0	0	0	0	394	405
NEV-4	0	1	0	100%	1	100%	93%	0	0	100%	0.00	0.00	0	0	0	0	410	410

MC Rate Factor ===> 0
(0= Off, 1= On)

USE Rate Factor===> 0
(0=STD, 1= Alternate)

Percent Avail Factor => 100% 100%
(Between 0% and 100%)

PAYLOAD Factor===> 1
(0=STD or Var, 1=DesertStr./Alternate)

Block Speed Fact 1
(0=NewStd, 1=Alternate, 2= For distance related block speeds.)

MAIN MENU
SCREEN INFORMATION

Aircraft Standard Planning Factors Input Screen

AIRCRAFT GROUND TIMES INPUT (AMMP AND DESERT STORM GROUND TIMES)															
Aircraft Type	Onload Time	Enroute Time	Offload Time	Expedited Time	Ofld/Onld Home Time	Onload Time	Enroute Time	Offload Time	Expedited Time	Ofld/Onld Home Time	Onload Time	Enroute Time	Offload Time	ERO Time	Ofld/Onld Home Time
KC-135	3.50	2.50	2.00	2.50	4.00	3.5	2.5	2.3	2.5	0.75	3.5	2.5	2	2.5	4
C-5	4.25	3.25	3.25	2.00	8.00	4.6	3.65	3.25	2	0.75	4.25	3.25	3.25	2	8
C-141	2.25	2.25	2.25	1.25	6.00	2.5	2.5	2.25	1.25	0.75	2.25	2.25	2.25	1.25	6
C-17	2.25	2.25	2.25	1.75	6.00	2.25	2.25	2.25	1.75	0.75	2.25	2.25	2.25	1.75	6
KC-10	4.25	3.25	3.25	3.25	5.00	4.35	3.45	3.25	3.25	0.75	4.25	3.25	3.25	3.25	5
DC-10	5.00	1.50	3.00	3.00	5.00	5	1.5	3	3	0.75	5	1.5	3	3	5
B-747F (Mix)	5.00	1.50	3.00	3.00	5.00	5	1.5	3	3	0.75	5	1.5	3	3	5
MD-11F	5.00	1.50	3.00	3.00	5.00	5	1.5	3	3	0.75	5	1.5	3	3	5
WBP Equiv	5.00	1.50	3.00	3.00	3.00	5	1.5	3	3	0.75	5	1.5	3	3	3
WBC Equiv	5.00	1.50	3.00	3.00	3.00	5	1.5	3	3	0.75	5	1.5	3	3	3
NBC	3.50	1.50	3.00	1.25	3.00	3.5	1.5	3	1.25	0.75	3.5	1.5	3	1.25	3
NEW-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEW-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEW-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEW-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cap. Limit==>	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0
GND. Time Factor ==>	0														
(0 or 1)															
MAIN MENU					SCREEN INFORMATION										

Aircraft Ground Times Input Screen

AIRCRAFT ALLOCATION															
Aircraft Type	Cargo		Pax	Acft MC Rates	Cycle 1 Cargo	Cycle 1 Pax	Cycle 2 Cargo	Cycle 2 Pax	Acft MC Rates	Cycle 3 Cargo	Cycle 3 Pax	Acft MC Rates	Cycle 3 Cargo	Cycle 3 Pax	Cycle 3
	CYCLE 1				CYCLE 2					CYCLE 3					
KC-135	0	0		100%	0	0	0	0		0	0		0	0	
C-5	50	0		100%	50	0	40	0		65	0		65	0	
C-141	50	0		100%	50	0	40	0		40	0		40	0	
C-17	50	0		100%	50	0	40	0		66	0		66	0	
KC-10	30	0		100%	30	0	30	0		27	0		27	0	
DC-10	30	0		100%	30	0	30	0		10	0		10	0	
B-747F (Mix)	0	0		100%	0	0	0	0		10	0		10	0	
MD-11F	0	0		100%	0	0	0	0		20	0		20	0	
WBP Equiv	0	30		100%	0	30	0	30		0	24		0	24	
WBC Equiv	0	0		100%	0	0	0	0		10	0		10	0	
NBC	0	0		100%	0	0	0	0		33	0		33	0	
NEW-1	0	0		100%	0	0	0	0		0	0		0	0	
NEW-2	0	0		100%	0	0	0	0		0	0		0	0	
NEW-3	0	0		100%	0	0	0	0		0	0		0	0	
NEW-4	0	0		100%	0	0	0	0		0	0		0	0	
TOTAL					210	30		180	30				281	24	
MAIN MENU					SCREEN INFORMATION										

Aircraft Allocation Screen

ALLOWABLE AIRCRAFT CARGO AND CARGO REQUIREMENTS INPUT													
Aircraft Type	Outsize Cargo	OverSize Cargo	Bulk Cargo	Pax	Cycle 1 Limit	Cycle 2 Limit	Cycle 3 Limit	Cycle 4 Limit	Cycle 1 Tons & Pax	Tons/Pax Per Day	Cycle 2 Tons & Pax	Tons/Pax Per Day	
					CYCLE 1	CYCLE 2	CYCLE 3	CYCLE 4					
KC-135	0%	0%	100%	100%					Outsize	4,698	54	4,698	54
C-5	40%	80%	100%	100%	TOTAL	TOTAL	TOTAL	TOTAL	OverSize	12,692	146	12,692	146
C-141	0%	80%	100%	100%	TOTAL	TOTAL	TOTAL	TOTAL	Bulk	8,531	98	8,531	98
C-17	40%	80%	100%	100%	TOTAL	TOTAL	TOTAL	TOTAL	Passengers	35,681	410	35,681	410
KC-10	0%	40%	100%	100%	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL CARGO	25,921		25,921	
DC-10	0%	0%	100%	100%	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL PAX	35,681		35,681	
B-747F (Mix)	0%	0%	100%	100%					Cycle Name	CYCLE 1		CYCLE 2	
MD-11F	0%	0%	100%	100%					Closure:	87		87	
WBP Equiv	0%	0%	100%	100%					Tons/Day:	298		298	
WBC Equiv	0%	0%	100%	100%					Pax/Day:	410		410	
NBC	0%	0%	100%	100%									
NEW-1	0%	0%	0%	0%									
NEW-2	0%	0%	0%	0%									
NEW-3	0%	0%	0%	0%									
NEW-4	0%	0%	0%	0%									

MAIN MENU
SCREEN INFORMATION

Allowable Aircraft Cargo and Cargo Requirements Input Screen

AIRCREW CALL-UP, AIRCREW LIMITS INPUT													
Aircraft Type	Crew Showtime	Crew Ratio Cargo	A/C Alloc. Pax	Active Crews	Reserve Crews	Percent Call-Up	Crew Ratio	Normal Limit	Waived Limit	Waiver Factor	Select		
KC-135	2.5	0	0	0	0	100%	0	Percent DNIF:	8%	5%	0	8%	
C-5	3.5	40	0	72	72	100%	4	Percent on Leave:	3%	2%	0	3%	
C-141	2.5	40	0	72	40	100%	3	Percent Trng/TDY:	2%	1%	0	2%	
C-17	2.5	40	0	120	80	100%	5	Percent Unqual:	1%	1%	0	1%	
KC-10	3	30	0	60	45	100%	4	30-Day Limit:	150	175	0	150	
DC-10	1	30	0	45	105	100%	5	90-Day Limit:	400	425	0	400	
B-747F (Mix)	1	0	0	0	0	100%	0	30-Day Time:	45	50	0	45	
MD-11F	1	0	0	0	0	100%	0	90-Day Time:	135	140	0	135	
WBP Equiv	1	0	30	150	0	100%	5	Basic Crew Day:	16	18	0	16	
WBC Equiv	1	0	0	0	0	100%	0	Aug Crew Day:	20	24	0	20	
NBC	1	0	0	0	0	100%	0	Crew Rest Period:	12	10	0	12	
NEW-1	0	0	0	0	0	100%	0	% Augment Factor ==>	0%	0%		100.0%	
NEW-2	0	0	0	0	0	100%	0	Waiver Factor ==>			0		
NEW-3	0	0	0	0	0	100%	0	(1=Yes , 0=No)					
NEW-4	0	0	0	0	0	100%	0	30 & 90 Day Limit Factors==>			150	400	

Crew Limit Factor==>

(0=no limit, 1=limit.)

Call Up Factor==>

(Between 0% and 100%)

MAIN MENU

SCREEN INFORMATION

Aircrew Call-Up, Aircrew Limits Input Screen

ROUTING INPUTS										
Base Name						Base Name				
DIST	WIND	STOP	STAGE	DIST	WIND	STOP	STAGE			
CYCLE 1						CYCLE 2				
ONLOAD: CHARLESTON AFI	0	0	0	0	ONLOAD: MCGUIRE AFB	0	0	0	0	
POINT 2: MILDENHALL	3,508	30	2	1	POINT 2: RAMSTEIN AB	3,372	30	2	1	
POINT 3: KING ABDUL AZIZ	2,698	30	3	1	POINT 3: DHAHRAN INTL	2,402	30	3	1	
POINT 4: MILDENHALL	2,698	25	2	1	POINT 4: RAMSTEIN AB	2,402	25	2	1	
POINT 5: MILDENHALL	0				POINT 5: RAMSTEIN AB	0				
POINT 6: MILDENHALL	0				POINT 6: RAMSTEIN AB	0				
POINT 7: MILDENHALL	0				POINT 7: RAMSTEIN AB	0				
POINT 8: MILDENHALL	0				POINT 8: RAMSTEIN AB	0				
POINT 9: MILDENHALL	0				POINT 9: RAMSTEIN AB	0				
POINT 10: MILDENHALL	0				POINT 10: RAMSTEIN AB	0				
ONLOAD: CHARLESTON AFI	3,508	-30	1	1	ONLOAD: MCGUIRE AFB	3,372	-30	1	1	

PUSH TO RENEW THE DISTANCES

Stop Factor
 (Blank=Waypoint w/o stop, 0=None, 1=Onload, 2=Enroute,
 3=Offload, 4=Engine Running Offload (ERO),
 5=Onload/Offload Combination, Non-standard Ground Delay or Home)

In/Out Factor =====>

(1=Yes, 0=No)

Stage Factor USE "+" FOR TAILWIND AND "-" FOR HEADWIND
 (1=Yes, Blank=No) NOTE: ENTER THE OFFLOAD LOCATION PRIOR TO POINT 6 ABOVE

MAIN MENU SCREEN INFORMATION

Routing Inputs Screen

AIRCRAFT MOG SUMMARY - "OR" VALUES																
Aircraft Type	Cargo	Pax	Work MOG	MOG Prime	MOG Interval	MOG Cyc1	%Acft1	Eq Acft1	Cargo	Pax	Work MOG	MOG Prime	MOG Interval	MOG Cyc2	%Acft2	Eq Acft2
CYCLE 1									CYCLE 2							
KC-135	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
C-5	50	0	12	33	1.30	2.50	20.83%	50	40	0	12	27	1.42	2.29	19.05%	40
C-141	50	0	24.5	23	0.44	5.10	20.83%	50	40	0	24.5	23	0.48	4.67	19.05%	40
C-17	50	0	24.5	41	0.44	5.10	20.83%	50	40	0	24.5	34	0.48	4.67	19.05%	40
KC-10	30	0	12	19	2.17	1.50	12.50%	30	30	0	12	21	1.90	1.71	14.29%	30
DC-10	30	0	12	18	2.00	1.50	12.50%	30	30	0	12	18	1.75	1.71	14.29%	30
B-747F (Mix)	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
MD-11F	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
WBP Equiv	0	30	12	18	2.00	1.50	12.50%	30	0	30	12	18	1.75	1.71	14.29%	30
WBC Equiv	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
NBC	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
NEW-1	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
NEW-2	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
NEW-3	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
NEW-4	0	0	0	0	0.00	0.00	0.00%	0	0	0	0	0	0.00	0.00	0.00%	0
			24.5	151			100.00%	240			24.5	141		16.76	100.00%	210

NB,WB & C-17 MOG Values ==>

In/Out Factor =====>

(1=Yes, 0=No (1=twice, 0=once))

MAIN MENU SCREEN INFORMATION

Aircraft MOG Summary "OR" Values Screen

AIRCRAFT CARGO ELIGIBILITY														
Aircraft Type	Outsize Cargo	Oversize Cargo	Bulk Cargo	Outsize Alloc 1	Oversize Alloc 1	Bulk Alloc 1	Total Alloc 1	Outsize Cargo	Oversize Cargo	Bulk Cargo	Outsize Alloc 2	Oversize Alloc 2	Bulk Alloc 2	Total Alloc 2
	CYCLE 1							CYCLE 2						
KC-135	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
C-5	2.60	5.20	6.50	2,290	5,156	2,622	7,967	2.08	4.15	5.19	2,290	4,912	2,374	7,214
C-141	0.00	1.25	1.57	0	1,242	632	1,919	0.00	1.25	1.56	0	1,479	715	2,172
C-17	2.74	5.47	6.84	2,408	5,423	2,758	8,380	2.18	4.37	5.46	2,408	5,167	2,497	7,588
KC-10	0.00	0.88	2.20	0	871	886	2,691	0.00	0.96	2.40	0	1,134	1,096	3,330
DC-10	0.00	0.00	4.05	0	0	1,633	4,963	0.00	0.00	4.04	0	0	1,849	5,617
B-747F (Mix)	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
MD-11F	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
WBP Equiv	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
WBC Equiv	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
NBC	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
NEW-1	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
NEW-2	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
NEW-3	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
NEW-4	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0	0	0	0
	5.34	12.81	21.15	4,698	12,692	8,531	25,921	4.26	10.72	18.64	4,698	12,692	8,531	25,921
MAIN MENU							SCREEN INFORMATION							

Aircraft Cargo Eligibility Screen

AIRCRAFT MOG SUMMARY - "AND" VALUES																
Aircraft Type	Cargo Pax		Percent Alloc.	MOG	Cargo Pax		Percent Alloc.	MOG	Cargo Pax		Percent Alloc.	MOG	Cargo Pax		Percent Alloc.	MOG
	CYCLE 1				CYCLE 2				CYCLE 3				CYCLE 4			
KC-135	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00
C-5	50	0	21.50%	2.58	40	0	18.94%	2.27	65	0	15.94%	0.56	65	0	15.94%	0.56
C-141	50	0	15.24%	3.73	40	0	16.67%	4.08	40	0	21.71%	1.30	40	0	21.71%	1.30
C-17	50	0	27.22%	6.67	40	0	23.83%	5.84	66	0	34.81%	2.09	66	0	34.81%	2.09
KC-10	30	0	12.79%	1.54	30	0	15.01%	1.80	27	0	6.38%	0.22	27	0	6.38%	0.22
DC-10	30	0	11.59%	1.39	30	0	12.73%	1.53	10	0	2.20%	0.08	10	0	2.20%	0.08
B-747F (Mix)	0	0	0.00%	0.00	0	0	0.00%	0.00	10	0	2.17%	0.08	10	0	2.17%	0.08
MD-11F	0	0	0.00%	0.00	0	0	0.00%	0.00	20	0	4.44%	0.16	20	0	4.44%	0.16
WBP Equiv	0	30	11.66%	1.40	0	30	12.82%	1.54	0	24	5.21%	0.18	0	24	5.21%	0.18
WBC Equiv	0	0	0.00%	0.00	0	0	0.00%	0.00	10	0	2.17%	0.08	10	0	2.17%	0.08
NBC	0	0	0.00%	0.00	0	0	0.00%	0.00	33	0	4.97%	0.30	33	0	4.97%	0.30
NEW-1	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00
NEW-2	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00
NEW-3	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00
NEW-4	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00	0	0	0.00%	0.00
			100.00%	17.31			100.00%	17.06			100.00%	5.04			100.00%	5.04
MAIN MENU					SCREEN INFORMATION											

Aircraft MOG Summary "AND" Values Screen

WORKING TABLE																
Aircraft	Max	CrgoAlc	PaxAlc	Cargo	Pax	Adjusted	Adjusted	MTM	Max	CrgoAlc	PaxAlc	Cargo	Pax	Adjusted	Adjusted	MTM
Type	Interval	Calc	Calc	Use Calc	Use Calc	CycTime	CycDays	PerDay	Interval	Calc	Calc	Use Calc	Use Calc	CycTime	CycDays	PerDay
CYCLE 1									CYCLE 2							
KC-135	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-5	1.34	6.50	0.00	10.60	0.00	67.04	2.79	6.50	1.56	5.19	0.00	10.60	0.00	62.46	2.60	5.19
C-141	1.72	1.57	0.00	8.56	0.00	86.10	3.59	1.57	1.60	1.56	0.00	10.70	0.00	64.17	2.67	1.56
C-17	0.94	6.84	0.00	15.15	0.00	46.80	1.95	6.84	1.09	5.46	0.00	15.15	0.00	43.60	1.82	5.46
KC-10	2.12	2.20	0.00	10.56	0.00	63.51	2.65	2.20	1.80	2.40	0.00	11.54	0.00	54.12	2.25	2.40
DC-10	2.19	4.05	0.00	10.00	0.00	65.57	2.73	4.05	2.04	4.04	0.00	10.00	0.00	61.08	2.54	4.04
B-747F (Mix)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MD-11F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WBP Equiv	2.14	0.00	22.33	0.00	9.98	64.31	2.68	0.00	1.99	0.00	22.34	0.00	10.00	59.76	2.49	0.00
WBC Equiv	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NBC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAX MOG:	49.00	21.15	22.33					21.15	49.00	18.64	22.34					18.64
CRW LIMITS==>	1								1							
MAIN MENU									SCREEN INFORMATION							

Working Table Screen

MAIN MENU									SCREEN INFORMATION								
BLOCK SPEEDS																	
CYCLE 1	KC-135	C-5	C-141	C-17	KC-10	DC-10	B-747F	MD-11F	WBP	Eq	WBC	Eq	NBC	NEW-1	NEW-2	NEW-3	NEW-4
CHARLESTON AFB/MUNI																	
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
KING ABDUL AZIZ	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MILDENHALL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
CHARLESTON AFB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
CYCLE 2																	
MCGUIRE AFB																	
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
DHAHRAN INTL	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
RAMSTEIN AB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		
MCGUIRE AFB	419	409	394	410	434	444	454	440	454	454	429	419	409	394	410		

Block Speeds Screen

MAIN MENU					SCREEN INFORMATION												
CORRECTED DISTANCES																	
CYCLE 1	KC-135	C-5	C-141	C-17	KC-10	DC-10	B-747F	MD-11F	WBP	Eq	WBC	Eq	NBC	NEW-1	NEW-2	NEW-3	NEW-4
CHARLESTON AFB/MUNI																	
MILDENHALL	3273.9	3268.6	3260.1	3269.1	3281.5	3286.3	3290.9	3284.4	3290.9	3290.9	3279.0	3273.9	3268.6	3260.1	3269.1		
KING ABDUL AZIZ	2517.8	2513.7	2507.2	2514.1	2523.7	2527.3	2530.9	2525.9	2530.9	2530.9	2521.8	2517.8	2513.7	2507.2	2514.1		
MILDENHALL	2546.2	2542.7	2537.1	2543.0	2551.1	2554.3	2557.3	2553.0	2557.3	2557.3	2549.5	2546.2	2542.7	2537.1	2543.0		
MILDENHALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILDENHALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILDENHALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILDENHALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILDENHALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILDENHALL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHARLESTON AFB	3778.9	3786.1	3797.5	3785.3	3768.9	3762.6	3756.6	3765.1	3756.6	3756.6	3772.1	3778.9	3786.1	3797.5	3785.3		
1-WAY DST	5791.8	5782.3	5767.3	5783.3	5805.2	5813.6	5821.8	5810.3	5821.8	5821.8	5800.8	5791.8	5782.3	5767.3	5783.3		
RT DIST	12116.9	12111.1	12101.9	12111.6	12125.2	12130.5	12135.6	12128.4	12135.6	12135.6	12122.5	12116.9	12111.1	12101.9	12111.6		
CYCLE 2	KC-135	C-5	C-141	C-17	KC-10	DC-10	B-747F	MD-11F	WBP	Eq	WBC	Eq	NBC	NEW-1	NEW-2	NEW-3	NEW-4
MCGUIRE AFB																	
RAMSTEIN AB	3147.1	3141.9	3133.8	3142.5	3154.3	3158.9	3163.4	3157.1	3163.4	3163.4	3152.0	3147.1	3141.9	3133.8	3142.5		
DHAHRAN INTL	2241.4	2237.8	2231.9	2238.1	2246.6	2249.9	2253.0	2248.6	2253.0	2253.0	2244.9	2241.4	2237.8	2231.9	2238.1		
RAMSTEIN AB	2266.6	2263.5	2258.6	2263.9	2271.1	2273.9	2276.5	2272.8	2276.5	2276.5	2269.6	2266.6	2263.5	2258.6	2263.9		
RAMSTEIN AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAMSTEIN AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAMSTEIN AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAMSTEIN AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAMSTEIN AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAMSTEIN AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAMSTEIN AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCGUIRE AFB	3632.5	3639.3	3650.3	3638.6	3622.8	3616.8	3611.0	3619.1	3611.0	3611.0	3626.0	3632.5	3639.3	3650.3	3638.6		
1-WAY DST	5388.5	5379.7	5365.7	5380.6	5400.9	5408.8	5416.4	5405.7	5416.4	5416.4	5396.9	5388.5	5379.7	5365.7	5380.6		
RT DIST	11287.6	11282.5	11274.6	11283.1	11294.8	11299.4	11303.9	11297.6	11303.9	11303.9	11292.5	11287.6	11282.5	11274.6	11283.1		

Corrected Distances Screen

MAIN MENU					SCREEN INFORMATION												
FLYING TIMES																	
CYCLE 1	KC-135	C-5	C-141	C-17	KC-10	DC-10	B-747F	MD-11F	WBP	Eq	WBC	Eq	NBC	NEW-1	NEW-2	NEW-3	NEW-4
CHARLESTON AFB/MUNI																	
MILDENHALL	7.81	7.99	8.27	7.97	7.56	7.40	7.25	7.46	7.25	7.25	7.64	7.81	7.99	8.27	7.97		
KING ABDUL AZIZ	6.01	6.15	6.36	6.13	5.81	5.69	5.57	5.74	5.57	5.57	5.88	6.01	6.15	6.36	6.13		
MILDENHALL	6.08	6.22	6.44	6.20	5.88	5.75	5.63	5.80	5.63	5.63	5.94	6.08	6.22	6.44	6.20		
MILDENHALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MILDENHALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MILDENHALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MILDENHALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MILDENHALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MILDENHALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHARLESTON AFB	9.02	9.26	9.64	9.23	8.68	8.47	8.27	8.56	8.27	8.27	8.79	9.02	9.26	9.64	9.23		
1-WAY FIT:	13.82	14.14	14.64	14.11	13.38	13.09	12.82	13.21	12.82	12.82	13.52	13.82	14.14	14.64	14.11		
RTFT:	28.92	29.61	30.72	29.54	27.94	27.32	26.73	27.56	26.73	26.73	28.26	28.92	29.61	30.72	29.54		
CYCLE 2	KC-135	C-5	C-141	C-17	KC-10	DC-10	B-747F	MD-11F	WBP	Eq	WBC	Eq	NBC	NEW-1	NEW-2	NEW-3	NEW-4
MCGUIRE AFB																	
RAMSTEIN AB	7.51	7.68	7.95	7.66	7.27	7.11	6.97	7.18	6.97	6.97	7.35	7.51	7.68	7.95	7.66		
DHAHRAN INTL	5.35	5.47	5.66	5.46	5.18	5.07	4.96	5.11	4.96	4.96	5.23	5.35	5.47	5.66	5.46		
RAMSTEIN AB	5.41	5.53	5.73	5.52	5.23	5.12	5.01	5.17	5.01	5.01	5.29	5.41	5.53	5.73	5.52		
RAMSTEIN AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RAMSTEIN AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RAMSTEIN AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RAMSTEIN AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RAMSTEIN AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RAMSTEIN AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RAMSTEIN AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MCGUIRE AFB	8.67	8.90	9.26	8.87	8.35	8.15	7.95	8.23	7.95	7.95	8.45	8.67	8.90	9.26	8.87		
1-WAY FIT:	12.86	13.15	13.62	13.12	12.44	12.18	11.93	12.29	11.93	11.93	12.58	12.86	13.15	13.62	13.12		
RTFT:	26.94	27.59	28.62	27.52	26.02	25.45	24.90	25.68	24.90	24.90	26.32	26.94	27.59	28.62	27.52		

Flying Times Screen

MAIN MENU					SCREEN INFORMATION											
GROUND TIMES																
CYCLE 1	KC-135	C-5	C-141	C-17	KC-10	DC-10	B-747F	MD-11F	WBP Eq	WBC Eq	NBC	NEW-1	NEW-2	NEW-3	NEW-4	
CHARLESTON AFB/MUNI																
MILDENHALL	2.50	3.25	2.25	2.25	3.25	1.50	1.50	1.50	1.50	1.50	1.50	0.00	0.00	0.00	0.00	
KING ABDUL AZIZ	2.00	3.25	2.25	2.25	3.25	3.00	3.00	3.00	3.00	3.00	3.00	0.00	0.00	0.00	0.00	
MILDENHALL	2.50	3.25	2.25	2.25	3.25	1.50	1.50	1.50	1.50	1.50	1.50	0.00	0.00	0.00	0.00	
MILDENHALL																
MILDENHALL																
MILDENHALL																
MILDENHALL																
MILDENHALL																
CHARLESTON AFB	3.50	4.25	2.25	2.25	4.25	5.00	5.00	5.00	5.00	5.00	3.50	0.00	0.00	0.00	0.00	
1-WAY GT	8.00	10.75	6.75	6.75	10.75	9.50	9.50	9.50	9.50	9.50	8.00	0.00	0.00	0.00	0.00	
TOTAL GT	10.50	14.00	9.00	9.00	14.00	11.00	11.00	11.00	11.00	11.00	9.50	0.00	0.00	0.00	0.00	
CYCLE 2	KC-135	C-5	C-141	C-17	KC-10	DC-10	B-747F	MD-11F	WBP Eq	WBC Eq	NBC	NEW-1	NEW-2	NEW-3	NEW-4	
MCGUIRE AFB																
RAMSTEIN AB	2.50	3.25	2.25	2.25	3.25	1.50	1.50	1.50	1.50	1.50	1.50	0.00	0.00	0.00	0.00	
DHAHRAN INTL	2.00	3.25	2.25	2.25	3.25	3.00	3.00	3.00	3.00	3.00	3.00	0.00	0.00	0.00	0.00	
RAMSTEIN AB	2.50	3.25	2.25	2.25	3.25	1.50	1.50	1.50	1.50	1.50	1.50	0.00	0.00	0.00	0.00	
RAMSTEIN AB																
RAMSTEIN AB																
RAMSTEIN AB																
RAMSTEIN AB																
RAMSTEIN AB																
MCGUIRE AFB	3.50	4.25	2.25	2.25	4.25	5.00	5.00	5.00	5.00	5.00	3.50	0.00	0.00	0.00	0.00	
1-WAY GT	8.00	10.75	6.75	6.75	10.75	9.50	9.50	9.50	9.50	9.50	8.00	0.00	0.00	0.00	0.00	
TOTAL GT	10.50	14.00	9.00	9.00	14.00	11.00	11.00	11.00	11.00	11.00	9.50	0.00	0.00	0.00	0.00	

Ground Times Screen

MISSION STATISTICS															
Aircraft Type	Cargo Alloc	Cargo Missions	Pax on Cargo	Pax Missions	Total Missions	Cargo Alloc	Cargo Missions	Pax on Cargo	Pax Missions	Total Missions	Cargo Alloc	Cargo Missions	Pax on Cargo	Pax Missions	Total Missions
CYCLE 1						CYCLE 2					CYCLE 3				
KC-135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-5	7,967	130	6,629	0	130	7,214	118	6,001	0	118	44,737	730	37,220	0	730
C-141	1,919	101	1,111	0	101	2,172	114	1,257	0	114	41,379	2,178	23,956	0	2,178
C-17	8,380	186	2,049	0	186	7,588	169	1,855	0	169	177,649	3,948	43,425	0	3,948
KC-10	2,691	83	0	0	83	3,330	102	0	0	102	9,567	293	0	0	293
DC-10	4,963	80	0	0	80	5,617	91	0	0	91	6,822	110	0	0	110
B-747F (Mix)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MD-11F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WBP Equiv	0	0	0	77	77	0	0	0	79	79	0	0	0	59	59
WBC Equiv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NBC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEW-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEW-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEW-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NEW-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25,921	580	9,788	77	657	25,921	593	9,114	79	673	280,153	7,259	104,601	59	7,318
MAIN MENU					SCREEN INFORMATION										

Mission Statistics Screen

MISSION TIMES															
Aircraft Type	RT Fly Time	Ground Time	Cycle Time	1-Way Time	Return Time	RT Fly Time	Ground Time	Cycle Time	1-Way Time	Return Time	RT Fly Time	Ground Time	Cycle Time	1-Way Time	Return Time
	CYCLE 1					CYCLE 2					CYCLE 3				
KC-135	28.92	10.50	39.42	21.82	17.60	26.94	10.50	37.44	20.86	16.58	32.63	15.50	48.13	25.51	22.62
C-5	29.61	14.00	43.61	24.89	18.72	27.59	14.00	41.59	23.90	17.68	33.44	20.50	53.94	29.36	24.58
C-141	30.72	9.00	39.72	21.39	18.33	28.62	9.00	37.62	20.37	17.25	34.73	13.50	48.23	24.90	23.33
C-17	29.54	9.00	38.54	20.86	17.69	27.52	9.00	36.52	19.87	16.65	33.36	13.50	46.86	24.32	22.54
KC-10	27.94	14.00	41.94	24.13	17.81	26.02	14.00	40.02	23.19	16.83	31.49	20.50	51.99	28.52	23.47
DC-10	27.32	11.00	38.32	22.59	15.73	25.45	11.00	36.45	21.68	14.77	30.78	14.00	44.78	25.22	19.56
B-747F (Mix)	26.73	11.00	37.73	22.32	15.41	24.90	11.00	35.90	21.43	14.47	30.09	14.00	44.09	24.92	19.17
MD-11F	27.56	11.00	38.56	22.71	15.86	25.68	11.00	36.68	21.79	14.89	31.06	14.00	45.06	25.34	19.72
WBP Equiv	26.73	11.00	37.73	22.32	15.41	24.90	11.00	35.90	21.43	14.47	30.09	14.00	44.09	24.92	19.17
WBC Equiv	26.73	11.00	37.73	22.32	15.41	24.90	11.00	35.90	21.43	14.47	30.09	14.00	44.09	24.92	19.17
NBC	28.26	9.50	37.76	21.52	16.24	26.32	9.50	35.82	20.58	15.24	31.86	12.50	44.36	24.18	20.18
NEW-1	28.92	0.00	28.92	13.82	15.10	26.94	0.00	26.94	12.86	14.08	32.63	0.00	32.63	15.01	17.62
NEW-2	29.61	0.00	29.61	14.14	15.47	27.59	0.00	27.59	13.15	14.43	33.44	0.00	33.44	15.36	18.08
NEW-3	30.72	0.00	30.72	14.64	16.08	28.62	0.00	28.62	13.62	15.00	34.73	0.00	34.73	15.90	18.83
NEW-4	29.54	0.00	29.54	14.11	15.44	27.52	0.00	27.52	13.12	14.40	33.36	0.00	33.36	15.32	18.04
MAIN MENU						SCREEN INFORMATION									

Mission Times Screen

CAPABILITY STATISTICS															
Aircraft Type	Critical Leg	Max Payload	Average Payload	Block Speed	Cycle Prdctvty	Critical Leg	Max Payload	Average Payload	Block Speed	Cycle Prdctvty	Critical Leg	Max Payload	Average Payload	Block Speed	Cycle Prdctvty
	CYCLE 1					CYCLE 2					CYCLE 3				
KC-135	3,274	30.75	13.00	429.24	0.48	3,147	33.31	13.00	428.69	0.48	3,165	32.94	13.00	416.12	0.46
C-5	3,269	78.78	61.30	419.19	0.48	3,142	82.19	61.30	418.64	0.48	3,160	81.70	61.30	406.07	0.46
C-141	3,260	31.03	19.00	404.12	0.48	3,134	33.58	19.00	403.57	0.48	3,152	33.21	19.00	391.00	0.46
C-17	3,269	73.94	45.00	420.20	0.48	3,142	78.58	45.00	419.65	0.48	3,161	77.91	45.00	407.08	0.46
KC-10	3,282	80.71	32.60	444.30	0.48	3,154	82.29	32.60	443.75	0.48	3,173	82.06	32.60	431.18	0.46
DC-10	3,286	74.00	62.00	454.34	0.48	3,159	74.00	62.00	453.79	0.48	3,177	74.00	62.00	441.22	0.46
B-747F (Mix)	3,291	121.00	86.00	464.37	0.48	3,163	121.00	86.00	463.83	0.48	3,182	121.00	86.00	451.26	0.46
MD-11F	3,284	74.00	74.00	450.32	0.48	3,157	74.00	74.00	449.77	0.48	3,175	74.00	74.00	437.21	0.46
WBP Equiv	3,291	80.59	46.50	464.37	0.48	3,163	82.17	46.50	463.83	0.48	3,182	81.95	46.50	451.26	0.46
WBC Equiv	3,291	121.00	78.00	464.37	0.48	3,163	121.00	78.00	463.83	0.48	3,182	121.00	78.00	451.26	0.46
NBC	3,279	30.64	30.64	439.28	0.48	3,152	33.21	33.00	438.73	0.48	3,170	32.84	32.84	426.16	0.46
NEW-1	3,274	30.75	0.00	429.24	0.48	3,147	33.31	0.00	428.69	0.48	3,165	32.94	0.00	416.12	0.46
NEW-2	3,269	30.86	0.00	419.19	0.48	3,142	33.41	0.00	418.64	0.48	3,160	33.05	0.00	406.07	0.46
NEW-3	3,260	31.03	0.00	404.12	0.48	3,134	33.58	0.00	403.57	0.48	3,152	33.21	0.00	391.00	0.46
NEW-4	3,269	30.84	0.00	420.20	0.48	3,142	33.40	0.00	419.65	0.48	3,161	33.04	0.00	407.08	0.46
MAIN MENU						SCREEN INFORMATION									

Capability Statistics Screen

FLOW INTERVAL LIMITS												
Aircraft Type	Ramp Interval	Acft allc. Interval	Ute Interval	Stg Crew Interval	Burn Limit Intervals		Ramp Interval	Acft allc. Interval	Ute Interval	Stg Crew Interval	Burn Limit Intervals	
					90 Day	30 Day					90 Day	30 Day
	CYCLE 1						CYCLE 2					
KC-135	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-5	1.26	0.87	1.34	0.66	1.29	1.15	1.43	1.04	1.56	0.58	1.20	1.07
C-141	0.60	0.79	1.22	1.06	1.72	1.53	0.55	0.94	1.42	0.87	1.60	1.43
C-17	0.34	0.77	0.94	0.40	0.93	0.82	0.39	0.91	1.09	0.37	0.86	0.77
KC-10	2.12	1.40	1.79	0.78	1.67	1.49	1.80	1.33	1.67	0.78	1.56	1.38
DC-10	2.16	1.28	2.19	0.46	1.14	1.02	1.96	1.21	2.04	0.46	1.07	0.95
B-747F (Mix)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MD-11F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WBP Equiv	2.14	1.26	2.14	0.46	1.12	0.99	1.95	1.20	1.99	0.46	1.04	0.93
WBC Equiv	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NBC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAIN MENU					SCREEN INFORMATION							

Flow Interval Limits Screen

AIRCRAFT USE / UTE RATES														
Aircraft Type	Cargo Acft	Pax Acft	Prime Acft	Theory Ute/Use	Actual Ute/Use	Cargo Acft	Pax Acft	Prime Acft	Theory Ute/Use	Actual Ute/Use	Cargo Acft	Pax Acft	Prime Acft	Theory Ute/Use
	CYCLE 1					CYCLE 2					CYCLE 3			
KC-135	0	0	0	17.61	0.00	0	0	0	17.27	0.00	0	0	0	16.27
C-5	50	0	33	16.30	10.60	40	0	27	15.92	10.60	65	0	9	14.88
C-141	50	0	23	18.56	8.56	40	0	23	18.26	10.70	40	0	25	17.28
C-17	50	0	41	18.40	15.15	40	0	34	18.09	15.15	66	0	43	17.09
KC-10	30	0	20	15.99	10.56	30	0	22	15.61	11.54	27	0	4	14.54
DC-10	30	0	18	17.11	10.00	30	0	18	16.76	10.00	10	0	1	16.50
B-747F (Mix)	0	0	0	17.00	0.00	0	0	0	16.65	0.00	0	0	1	16.38
MD-11F	0	0	0	17.15	0.00	0	0	0	16.80	0.00	0	0	2	16.54
WBP Equiv	0	30	18	17.00	9.98	0	30	18	16.65	10.00	0	24	3	16.38
WBC Equiv	0	0	0	17.00	0.00	0	0	0	16.65	0.00	0	0	1	16.38
NBC	0	0	0	17.96	0.00	0	0	0	17.64	0.00	0	0	4	17.24
NEW-1	0	0	0	24.00	0.00	0	0	0	24.00	0.00	0	0	0	24.00
NEW-2	0	0	0	24.00	0.00	0	0	0	24.00	0.00	0	0	0	24.00
NEW-3	0	0	0	24.00	0.00	0	0	0	24.00	0.00	0	0	0	24.00
NEW-4	0	0	0	24.00	0.00	0	0	0	24.00	0.00	0	0	0	24.00
	210	30	152			180	30	142			208	24	93	
MAIN MENU					SCREEN INFORMATION									

Aircraft Use/Ute Rate Screen

AIRCRAFT STATISTICS										
Aircraft Type	Max on Ground	Average on Grnd	Missions per Day	Hours per Day	MTM per Day	Max on Ground	Average on Grnd	Missions per Day	Hours per Day	MTM per Day
CYCLE 1					CYCLE 2					
KC-135	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-5	3.17	2.61	15.77	530.00	6.50	2.72	2.24	13.70	424.00	5.19
C-141	1.31	1.31	12.52	428.09	1.57	1.40	1.40	13.57	428.09	1.56
C-17	2.40	2.40	23.01	757.50	6.84	2.06	2.06	19.98	606.00	5.46
KC-10	2.01	1.65	10.07	316.73	2.20	2.36	1.94	11.92	346.23	2.40
DC-10	2.29	1.26	9.83	300.00	4.05	2.46	1.35	10.65	300.00	4.04
B-747F (Mix)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MD-11F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WBP Equiv	2.33	1.28	9.98	299.25	0.00	2.51	1.38	10.73	300.00	0.00
WBC Equiv	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NBC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEW-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	13.51	10.52	81.18	2,631.57	21.15	13.51	10.38	80.56	2,404.32	18.64
MAIN MENU			CLICK TO SEE RELATED CHARTS				SCREEN INFORMATION			

Aircraft Statistics Screen

THROUGHPUT AND CLOSURE															
Aircraft Type	Cargo Closure	Passenger Closure	Tons per Day	Passengers per Day	Ute Limit Reason	Cargo Closure	Passenger Closure	Tons per Day	Passengers per Day	Ute Limit Reason	Cargo Closure	Passenger Closure	Tons per Day	Passengers per Day	Ute Limit Reason
	CYCLE 1					CYCLE 2					CYCLE 3				
KC-135	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT
C-5	8.24	0.00	967	804	UTE	8.59	0.00	840	699	UTE	178.16	0.00	251	209	RAMP
C-141	8.07	0.00	238	138	90 DAY	8.42	0.00	258	149	90 DAY	177.63	0.00	233	135	90 DAY
C-17	8.09	0.00	1,036	253	UTE	8.44	0.00	899	220	UTE	178.18	0.00	997	244	RAMP
KC-10	8.20	0.00	328	0	RAMP	8.57	0.00	389	0	RAMP	178.52	0.00	54	0	RAMP
DC-10	8.14	0.00	610	0	UTE	8.50	0.00	661	0	UTE	177.65	0.00	38	0	RAMP
B-747F (Mix)	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	RAMP
MD-11F	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	RAMP
WBP Equiv	0.00	7.74	0	3,343	RAMP	0.00	7.39	0	3,594	UTE	0.00	41.10	0	485	RAMP
WBC Equiv	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	RAMP
NBC	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	CREWS
NEW-1	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT
NEW-2	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT
NEW-3	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT
NEW-4	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT	0.00	0.00	0	0	NO ACFT
TOTAL	8.24	7.74	3,178	4,538		8.59	7.39	3,046	4,662		178.52	41.10	1,573	1,072	
MAIN MENU							CLICK TO SEE RELATED CHARTS				SCREEN INFORMATION				

Throughput and Closure Screen

RAMP USE OPTIMIZATION													
Aircraft Type	OPT. CARGO Mission/ Day	Max Msn. Per Day	OPT. PAX Mission/ Day	Ramp Share	Daily Throughput	Missions TOTAL	Outsize Throughput	Out-Over Throughput	All Cargo Throughput	Pax Throughput	DailyCrg Thruput	DailyPaxWC Thruput	DailyOnlyPax Thruput
CYCLE 1													
KC-135	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
C-5	9.49	17.90	0.00	36.7%	581.79	9.49	232.72	465.43	581.79	484.03	581.8	484.0	0.0
C-141	3.57	13.94	0.00	5.6%	67.84	3.57	0.00	54.27	67.84	39.28	67.8	39.3	0.0
C-17	16.37	25.64	0.00	25.6%	736.55	16.37	294.62	589.24	736.55	180.04	736.5	180.0	0.0
KC-10	0.00	13.42	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
DC-10	4.30	10.98	0.00	15.4%	266.76	4.30	0.00	0.00	266.76	0.00	266.8	0.0	0.0
B-747F (Mix)	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
MD-11F	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
WBP Equiv	0.00	11.22	4.69	16.8%	0.00	4.69	0.00	0.00	0.00	1,572.01	0.0	0.0	1572.0
WBC Equiv	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
NBC	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
NEW-1	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
NEW-2	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
NEW-3	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
NEW-4	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
TOTAL	33.73	93.10	4.69	100.0%	1,652.94		527.33	1108.94	1652.94	2275.37	1652.94	703.36	1572.01
MOG FOR==> NB		49	GND. Time Factor ==>				4,698	17,390	25,921	35,681	1,652.94		
WB		24	(0 or 1)				0				2,275.37		
C-17		49	RAMP SHARE BOUND ==>				100.0%		CARGO/DAY ==>				
CLOSURE =====>		16.72	CARGO-PAX THRG. BOUND ==>				0.1122466	0.06376969	0.06376895	0.06376969			
OPTIMIZED			OBJ.FNCT.VARIABLES =====>				0.0637697	0.06376969	0.06376969	0.06376969			
OBJ.FNC.VAL. =====>		3,188484543											
MAIN MENU				CLICK TO SEE RELATED CHARTS						OPTIMIZE RAMP USE			
SCREEN INFORMATION													
A/C Type	MOG	Work MOG	#Pax wCargo	#Pax w/oCargo	Outsz C	Oversz C	Bulk C	Pssg.	Avg Payld	1Way Time	Non-Ramp Interval	MOG Base	Ground Time
CYCLE 1													
KC-135	NB	12	0	46	0%	0%	100%	100%	13.00	21.8	0.00	4.00	
C-5	WB	7	51	51	40%	80%	100%	100%	61.30	24.9	1.34	6.50	
C-141	NB	12	11	120	0%	80%	100%	100%	19.00	21.4	1.72	4.50	
C-17	C17	12	11	90	40%	80%	100%	100%	45.00	20.9	0.94	4.50	
KC-10	WB	7	0	68	0%	40%	100%	100%	32.60	24.1	1.79	6.50	
DC-10	WB	7	0	180	0%	0%	100%	100%	62.00	22.6	2.19	6.00	
B-747F (Mix)	WB	7	0	335	0%	0%	100%	100%	86.00	22.3	0.00	6.00	
MD-11F	WB	7	0	315	0%	0%	100%	100%	74.00	22.7	0.00	6.00	
WBP Equiv	WB	7	0	335	0%	0%	100%	100%	46.50	22.3	2.14	6.00	
WBC Equiv	WB	7	0	0	0%	0%	100%	100%	78.00	22.3	0.00	6.00	
NBC	NB	12	0	0	0%	0%	100%	100%	30.64	21.5	0.00	6.00	
NEW-1	WB	7	0	0	0%	0%	100%	100%	0.00	13.8	0.00	0.00	
NEW-2	WB	7	0	0	0%	0%	100%	100%	0.00	14.1	0.00	0.00	
NEW-3	WB	7	0	0	0%	0%	100%	100%	0.00	14.6	0.00	0.00	
NEW-4	WB	7	0	0	0%	0%	100%	100%	0.00	14.1	0.00	0.00	
			Outsize		4698								
			Oversize		12692								
			Bulk		8531								
			Pssngs		35681								
			TOTAL		25921								

CREW SUMMARY										
Aircraft Type	Crews Avail	Crw Need per Stage	Totl Stg Crw Need for Cycle	CrwRqmnt for Cycle	CrwRqmnt for Ute	Crews Avail	Crw Need per Stage	Totl Stg Crw Need for Cycle	CrwRqmnt for Cycle	CrwRqmnt for Ute
CYCLE 1					CYCLE 2					C
KC-135	0	0	0	0	0	0	0	0	0	0
C-5	124	9	37	87	139	124	8	31	71	111
C-141	96	7	28	78	158	96	8	31	71	127
C-17	172	13	52	102	198	172	11	45	85	159
KC-10	90	6	22	52	98	90	7	26	56	98
DC-10	129	5	21	51	78	129	6	23	53	78
B-747F (Mix)	0	0	0	0	0	0	0	0	0	0
MD-11F	0	0	0	0	0	0	0	0	0	0
WBP Equiv	129	5	21	51	78	129	6	23	53	78
WBC Equiv	0	0	0	0	0	0	0	0	0	0
NBC	0	0	0	0	0	0	0	0	0	0
NEW-1	0	0	0	0	0	0	0	0	0	0
NEW-2	0	0	0	0	0	0	0	0	0	0
NEW-3	0	0	0	0	0	0	0	0	0	0
NEW-4	0	0	0	0	0	0	0	0	0	0
MAIN MENU					SCREEN INFORMATION					

Crew Summary Screen

AIR REFUELING									
Aircraft Type	Fuel BrnRts	Tot. Fuel.	Dest. Resr.	#ofRc A/C	A/C Blc.Sp	Offload Rqr. Offload Avlb.			
Please check the TANKERTYPE(s) # of RECEIVER A/C(s)							Total Offload Requirement		
<input checked="" type="checkbox"/> KC-135E	<input checked="" type="checkbox"/> F-117	6	9,380	24,000	9,380	6 370	136,274	==> 206,416	
<input checked="" type="checkbox"/> KC-135R/T	<input checked="" type="checkbox"/> F-4	3	9,715	25,000	9,715	3 370	70,142		
<input type="checkbox"/> KC-10	<input type="checkbox"/> F-15C	6	7,500	23,000	7,500	0 370	WILL NOT FLY		
	<input type="checkbox"/> F-15E	3	10,586	25,000	10,586	0 370	WILL NOT FLY		
	<input type="checkbox"/> EF-111	6	9,715	30,000	9,715	0 370	WILL NOT FLY		
	<input type="checkbox"/> F-16	6	5,360	20,000	5,360	0 370	WILL NOT FLY		
LEG DISTANCE ==> 1,473	<input type="checkbox"/> A/OA-10	6	4,121	20,000	4,121	0 370	WILL NOT FLY		
	<input type="checkbox"/> C-141	6	13,902	40,000	13,902	0 370	WILL NOT FLY		
	<input type="checkbox"/> C-17	6	18,002	45,000	18,002	0 386	WILL NOT FLY		
	<input type="checkbox"/> C-5	6	23,450	55,000	23,450	0 385	WILL NOT FLY		
	<input type="checkbox"/> C-130	6	5,360	45,000	5,360	0 395	WILL NOT FLY		
	<input type="checkbox"/> KC-10	6	17,755	327,000	40,000	0 410	WILL NOT FLY		
	<input type="checkbox"/> KC-135E	0	10,921	160,000	30,000	0 395	WILL NOT FLY		
	<input type="checkbox"/> KC-135R/T	0	10,921	180,000	30,000	0 395	WILL NOT FLY		
	Req.KC-135E ==>	0	10,921	160,000	30,000	395	89,285		
	Req.KC-135R/T==>	2	10,921	180,000	30,000	395	109,285		
	Req.KC-10 ==>	0	17,755	327,000	40,000	410	WILL NOT FLY		
Calculated Distance ==> 1,473									
By Distance Calculator									
MAIN MENU							DISTANCE CALC.		
SCREEN INFORMATION							TANKER OPTIMIZATION		

Air Refueling Screen

AEROMEDICAL EVACUATION														
Aircraft Type	# Of Evcs	Load. Pln. Factors	Crw. Pln.Fac.	AE Crw./AC	Cyc.T.	AE Msn.	AE Crw	# Of Evcs	Load. Pln. Factors	Crw. Pln.Fac.	AE Crw./AC	Cyc.T.	AE Msn.	AE Crw
CYCLE 1								CYCLE 2						
KC-135	500	50	1.25	5	4	10.00	250	500	50	1.25	5	4	10.00	250
C-5	500	74	1.25	5	4	6.76	169	500	74	1.25	5	4	6.76	169
C-141	500	63	1.25	7	4	7.94	278	500	63	1.25	7	4	7.94	278
C-17	500	45	1.25	7	4	11.11	389	500	45	1.25	7	4	11.11	389
KC-10	500	35	1.25	5	4	14.29	357	500	35	1.25	5	4	14.29	357
DC-10	500	24	1.25	5	4	20.83	521	500	24	1.25	5	4	20.83	521
B-747F (Mix)	500	30	1.25	10	4	16.67	833	500	30	1.25	10	4	16.67	833
MD-11F	500	39	1.25	5	4	12.82	321	500	39	1.25	5	4	12.82	321
WBP Equiv	500	120	1.25	10	4	4.17	208	500	120	1.25	10	4	4.17	208
WBC Equiv	500	110	1.25	10	4	4.55	227	500	110	1.25	10	4	4.55	227
NBC	500	35	1.25	5	4	14.29	357	500	35	1.25	5	4	14.29	357
NEW-1	500	39	1.25	7	4	12.82	449	500	39	1.25	7	4	12.82	449
NEW-2	500	34	1.25	5	4	14.71	368	500	34	1.25	5	4	14.71	368
NEW-3	500	38	1.25	5	4	13.16	329	500	38	1.25	5	4	13.16	329
NEW-4	500	42	1.25	5	4	11.90	298	500	42	1.25	5	4	11.90	298
MAIN MENU								SCREEN INFORMATION						

Aeromedical Evacuation Screen

DISTANCE CALCULATION							
<p>FOR DISTANCE CALCULATION: PLEASE CHOOSE THE LEAVING AND ARRIVING POINTS FROM THE WINDOWS BELOW or ENTER THE LATITUDE-LONGITUDE VALUES of RELATED POINTS.</p>							
LEAVING POINT				ARRIVING POINT			
WRIGHT-PATTERSON AFB				NELLIS AFB			
DISTANCE CALCULATED =====>				1,472.60 NM			
LATITUDE	LONGITUDE			LATITUDE	LONGITUDE		
44	55	<===== ENTER DEGREE VALUES =====>		21	22	<===== ENTER DEGREE VALUES =====>	
45	12	<===== ENTER MINUTE VALUES =====>		37	33	<===== ENTER MINUTE VALUES =====>	
<input type="checkbox"/> =====> CHECK IF NORTH <input checked="" type="checkbox"/> =====> CHECK IF WEST				<input type="checkbox"/> =====> CHECK IF NORTH <input checked="" type="checkbox"/> =====> CHECK IF WEST			
MAIN MENU				BACK TO THE AIR REFUELING SCREEN			
SCREEN INFORMATION				PUSH FOR ICAO LIST			

Distance Calculation Screen

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14. ABSTRACT <p>This research is focused on the mobility system modeled by the AMC mobility planner's calculator (AMPCALC). AMPCALC is developed as a user-friendly tool and allows the user to easily carry out strategic airlift, air refueling and aeromedical evacuation calculations that were covered in the Air Force Pamphlet 10-1403. In this study, Excel software and its macro language Visual Basic for Application are two main tools.</p> <p>The methodology of the thesis examines fundamental aspects of the mobility system in AMPCALC. Formulation logic of the mobility cycle is discussed. Ramp use optimization and tanker optimization processes are presented. Verification and validation studies of AMPCALC are conducted.</p> <p>Sensitivity analysis of the model includes response surface study. To be able to investigate the main effects and interaction effects of the input factors on the closure, a 2⁶ factorial design is performed. No linear relations are observed, but some relations between inputs and closure time are observed.</p>					
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